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G. L. FARKAS, G. FEKETE, V. FRENYÓ, T. HORTOBÁGYI,
P. JUHÁSZ-NAGY, I. MÁTHÉ, S. SÁRKÁNY, T. SIMON, B. ZÓLYOMI

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ULTRAVIOLET FLUORESCENCE MICROSCOPY OF STARCH GRAINS IN SHOOT TIPS OF UNTREATED AND MORPHACTIN-TREATED APPLE TREES

By

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(Received March 18, 1974)

The presence of starch grains was proven in the cells of the subapical, elongating tissue of the growing shoot tips of apple trees and in the basal part of the youngest leaf primordia next to the apex.

The distribution of the starch grains in the cells of tissues of the shoot tip does not show any correlation with the vertical or horizontal orientation of the shoots, nor with the effect of morphactin treatment eliminating the geotropic sensitivity.

The specificity of the Alcian Blue 8GX — periodic acid — Schiff reagent (AB-PAS) used for the test for starch is greatly enhanced by the application of ultraviolet fluorescence microscopy.

Introduction

Shoots of apple trees react very sensitively to experimentally induced changes in their orientation. Forcing the vertically growing shoots into a horizontal position changes growth rate and degree of ramification and flower bud formation. Gravity, of course, has a well known direct effect on apical dominance and on flower formation, similarily to other fruit trees and woody plants (see review by JANKIEWICZ, 1971).

Spraying with growth regulators of the morphactin type in a concentration of 100 ppm or higher leads to partial loss of direction in shoot growth (BUBÁN et al., 1969a). Loss of geotropic sensitivity of plant organs was reported by KHAN (1967) and also by KRELLE and LIBBERT (1968).

Our present work investigated the existence if any, of relationship between the geotropical sensitivity of growing shoots and the presence of starch grains, or their possible role as statoliths, in the tissue of the shoot tips of *Malus domestica*.

Material and method

The material (Jonathan variety on M 4 rootstock) was obtained from an apple orchard of the Institute of Pomology at the University of Hohenheim. Tips from shoots growing in three different orientations were used:

1. shoots growing vertically upwards (V),
2. shoots originally growing vertically but tied down horizontally (VH),
3. shoots growing horizontally (H).

The VH twigs were tied horizontally at the time of the treatment (4. 7. 1972). Half of the shoots (experimental shoots VM, VHM, HM) were treated with morphactin (= chlorflurenol, 30 ppm). The two young leaves next to the growing point were dipped for a few seconds into the morphactin solution. The treated young leaves had approximately half of the surface area of fully developed leaves. Six shoots were treated identically and constituted one experiment.

Three days after the treatment, the shoot tips (2 cm long) were cut and brought into the laboratory. During transport, preparation and fixation, the cuttings were kept in their original position (vertical or horizontal). Ethanol : formalin : picric acid 6 : 1 : 1.3 was used for fixation. The 10 to 12 micron thick sections prepared after embedding in paraplast were stained with Alcian Blue 8GX — periodic acid — Schiff reagent (AB-PAS), according to MOWRY (1963). The sections were first stained with a special Alcian Blue solution (1% Alcian Blue 8GX in 3% glacial acetic acid, for 2 hours) before being oxidized with periodic acid. The Schiff reagent was prepared according to the standard technique of GRAUMANN (1953), but with trichloro acetic acid (BLOCH and GODMAN, 1955). For the preparation of the sulfurous acid, $Na_2S_2O_5$ was substituted by $NaHSO_3$ (cf. MOWRY, l.c.). Poststaining with Harris-haematoxylin and picric acid background staining was omitted.

For the UV fluorescence observations, the filter combinations described by DIBOLL (1967) were used. The microphotographs for the UV fluorescence observations were made with Kodak High Speed Ektachrome film and for visible light with Kodachrome II Type A.

The shoot tips used for the sections were about 3 to 4 mm long. Thus it was possible to examine the apex, the youngest leaf primordia, as well as the subapical zone. The microscopic observations were made under visible light or UV.

Results

On the third day after the treatment, the tips of the control shoots which were tied horizontally (VH) curved slightly upwards. The experimental shoots tied down (VHM) gave no uniform reaction: One tip curved slightly upward, a second one vertically upward, and the rest remained in the horizontal orientation. These results are in agreement with the observations of BUBÁN et al. (1969a) mentioned above, indicating that there exists no definite direction for shoot tip growth. The tips are still capable of growing by elongation, but lost their sensitivity for gravity.

By the combined use of visible light and UV microscopy, more detailed information on the cell content was obtained. Examination with visible light provides data about the nature of the polysaccharids by the RITTER and OLSON principle (MOWRY, 1963). The two known types of polysaccharides could be identified in the subapical pith cells of apple shoot tips (Fig. 1.). Neutral carbohydrates rich in vicinal hydroxyl groups were present in the starch grains, as indicated by their red color. Complex carbohydrates with acid groups were stained blue and found in the individual layers of the cell wall where also neutral carbohydrates can be located.

The sections provided a suitable material for a good survey in visible light, since the sections of the cell elements were distinctly stained and were clearly identified. However, the coloration was not absolutely specific because all other cell structures containing carbohydrates were also stained (cf. DIBOLL, 1967). This difficulty was overcome by fluorescence microscopy. The distribution and localisation of the starch grains in the cells of the different tissues

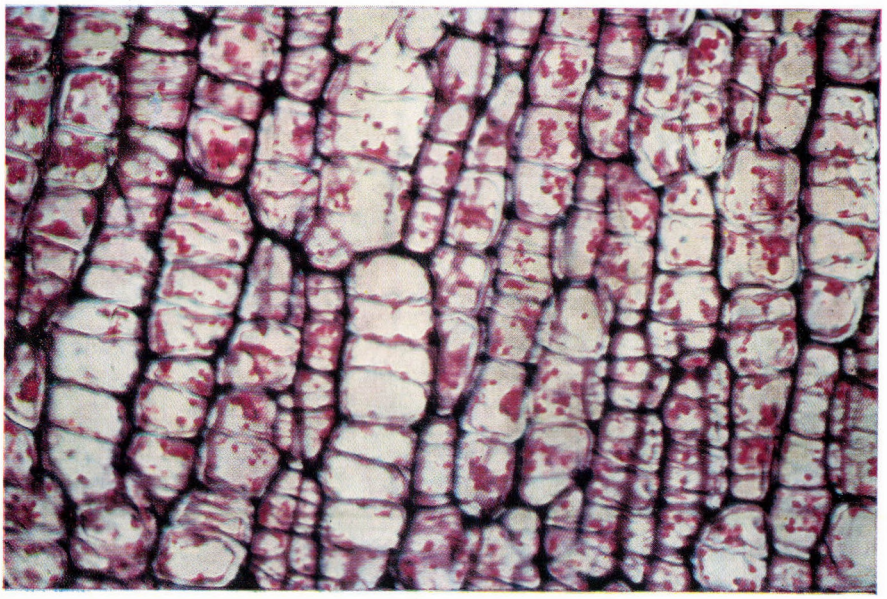

Fig. 1. Bright field microscopy. Approximately 550 : 1

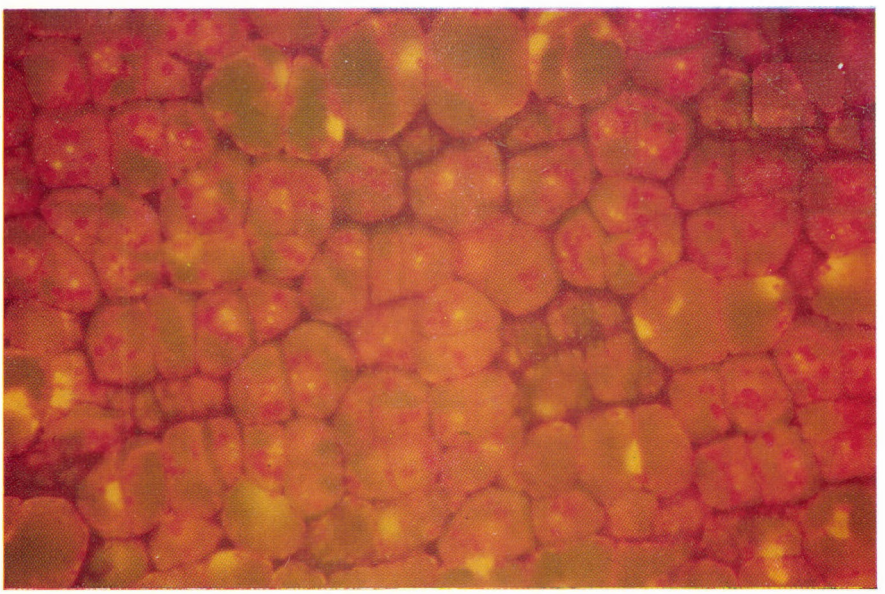

Fig. 2. Blue-violet microscopy. Approximately 800 : 1

Figs. 1. and *2.* Section of AB-periodic acid-Schiff-colored cells of the subapical pithtissue with starch grains

were clearly recognized under ultraviolet light (Fig. 2). The starch grains and also the cell wall fluoresced red while the cytoplasm and nucleoli appeared yellow. The latter seems to be the primary fluorescence since the yellow fluorescence appeared also in the unstained material. According to DIBOLL, fluorescence does not change whether or not RNA is extracted from the cells by trichloroacetic acid (DIBOLL, 1967, p. 102).

The highest frequency of starch grains was found in cells of the subapical pith tissue, including the peripheral part next to the procambium. In a smaller quantity, starch grains were always found in cells of the outer part of the procambium where the starch sheath would develop. Cells at the basis of young leaf primordia contained less starch. Starch grains were completely absent in the cells of the apex meristem and in the apical part of young leaf primordia.

The frequency and distribution of the starch grains in the cells of the different tissues did not vary with the treatments applied and was the same as in the control shoots. In some instances the starch grains were assembled in the cells of the treated shoots (VM, HM, VHM). However, no sufficient observations were made to allow a generalization of this finding.

Since the distribution of the starch grains in the cells of the shoot apex did not change subsequent to the forcing of the shoot in a different orientation, it appears that the starch does not act as a statolith in these tissues. It is clearly seen in Fig. 2 that starch grains are tightly embedded in the cytoplasm and that their distribution is determined by the location of cytoplasm. This suggests that the curvature response of the subapical shoot zone resulting from the cell elongation at the lower side of the shoot is independent from the location of the starch grains in these cells.

Discussion

Dislocation of starch grains caused by gravity was first observed by NAEGELI (1858). The term "statolith starch" was introduced by HABERLANDT (1900) and NĚMEC (1901). This starch is located in cells at the perception site of the gravitational stimulus, such as the root cap, the tip of the coleoptile, and the starch sheath of stems. Some correlation may exist between the localization of statolith starch and Golgi vesicles in the cell (SIEVERS, 1967). Ageotropic roots do not contain statolith starch and it is not hydrolyzed in starving plants (GUTTENBERG, 1963). This stresses a special role of plants starch grains. However, the fruitbodies of geotropically sensitive fungi contain no starch, and this observation often raised argument against the statolith function of the starch grains. Furthermore, the function of calcium oxalate crystals in Triticum (PRANKHERD, 1920) or of mitochondria as statoliths (cf. WILKINS, 1966) are occasionally discussed.

It is not required here to refer to papers on the geotropical behaviour of roots, regarding statoliths (PILET et al., 1971; 1971a; SIEVERS and VOLKMANN, 1972; GOLDSMITH and RAY, 1973), geoelectric theory (HAGER, 1971 and review by WILKINS, 1966) and other factors (PILET and NOUGAREDE, 1970, CANDE et al. 1973). Nevertheless, we can site merely few publications on the geotropical sensitivity of the shoots of woody plants. BORKOWSKA et al. (1967), working with *Populus* and *Malus* (cv. Wealthy), proved that the effect of the gravitational excitation (e.g. by keeping trees in a horizontal position during a limited time period), given during dormancy, can be observed during the whole following vegetative period. The ramification scheme of the plant and the pattern of growth are such as if the plant had remained in the horizontal position during the total vegetative period. It was shown that growth inhibitors and growth regulators are translocated during the inductive period between the upper and lower sides of the shoot in the cortex. The subsequent events occur in several steps (JANKIEWICZ, 1971). The inductive period during the dormant stage may be surprisingly short (one to two weeks) in some cases of the treatments of BORKOWSKA. The phenomenon of the "geotropic memory" of the plant is difficult to explain. Probably the treatment of BORKOWSKA (1966) induces an irreversible rearrangement during dormancy in the localization of the endogenous growth regulators. However, it is known that polar auxin transport also takes place in the dormant state. According to PIANIAZEK and SANIEWSKI (1968) the depletion of starch and the sprouting of buds are initiated by endogenous cytokinins. The auxins, produced by the growing leaves, stimulate the breakdown of starch and the resulting sugar is used for the initial shoot growth and for the cambial growth. Morphactins have the capacity to disturb this system of endogenous growth regulators. Treatment in the range of 100 ppm or more cause a delay of bud opening in spring (BUBÁN et al., 1969b). On the other hand, it is remarkable that the changes in starch content in the spurs cannot be regarded as a direct cause of flower initiation but only as an excellent indicator of the specific metabolic processes (GROCHOWSKA, 1973).

BARLOW (1973) observed on St. Julien plum that the curvature reaction of shoots is slightly reduced after removal of leaves and largely diminished by removal of the shoot tip. The curvature is almost entirely hindered by the two treatments applied simultaneously. However, when the stump of the shoot is supplied with synthetic auxin, and gibberellin was given on the petiole stump, the disposition for curving recovers. In the case of apple rootstock M 7 the removal of leaves and shoot tips had less effect.

Experimental results concerning the geotropic curvature response of the higher plants are complex and partly contradictory. Our simple experiment may represent a small contribution to this problem. The position of the starch grains within the cells of the subapical shoot zone was found to be unrelated to the direction of growth of the shoot tip. This does not preclude the theoretical

possibility that in the cells of plants organs with a low cytoplasmic viscosity or with heavier starch grains the statolith theory may be valid. The question whether the starch accumulation is caused by a metabolic disturbance (TREICHEL, 1971) resulting from a too strong morphactin concentration of the treatment was outside the scope of this work. The range of morphactin concentrations used in these experiments was low and sufficient only to increase the flower bud formation of apple or peach (BUBÁN, 1972; BUBÁN et al., 1972).

The Schiff reagent, known since 1924, was first used by HOTCHKISS (1948) as a test for polysaccharids. The periodic acid Schiff staining (PAS) developed by HOTCHKISS became the traditional test for polysaccharides. The versatility of this test is high, because the Schiff reagent can be prepared with about forty different basic dyes (cf. RUTHMANN, 1966), yielding absolute specificity for many tests. Differentation between various polysaccharides was made possible by the modification of MOWRY (1963) who introduced a specific grade of Alcian blue (Alcian Blue 8GX). The specificity of this stain is (also according to our experiences) greatly increased by the use of ultraviolet fluorescence microscopy introduced by DIBOLL (1967). Other and in some instances easier tests for starch (SEIDEMANN, 1966; CZAJA, 1969) were not examined in this study.

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LIGHT INTENSITY STUDIES IN BEECHWOODS OF DIFFERENT AGES

By

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Synchronous photoelectrical light measurements (light intensity measurements) were made with the lux-meter, in 32 repetitions and according to sunheight categories, in three age-groups of beechwoods, at the herbaceous layer and on a nearby clearing. The purpose of the work was to demonstrate the light variabilities affecting the species living in the undergrowth in the three age-groups of diverse stand structures. The differences in the state of light intensity are the smallest in the period of developed foliage in the stands of different ages. In the transitional vegetative period (the process of leaf-growing) the differences in light intensity are higher. In the leafless state, the trunk-branch structure in the young and old stands lead to the formation of similar light conditions in spring, while the foliage structure lead to similar light conditions in the middle-age and old-age stands.

Deficiency in light may temporarily, arise especially in plant associations in wich the shortage of water or the high temperature does not appear as an obstacle in the formation of developed supraterranean, many-layered vegetation levels, whereas the importance of light as an ecological factor increases. The light climate of plant associations is hardly examined and known.

The examinations of production-ecological aspects of plant stands, the works of SAEKI, MONSI and SAEKI, etc., which led to the elaboration of various light distribution models, and further to that of association photosynthesis models (FEKETE, 1972; light as regulating factor) should be distinguished from analyses directed towards the light toleration of the individual species of associations (light as limiting factor).

ZELLNIKER (1969), in her summarizing work, reviews the great number of light measurements made in natural plant associations. ALEKSEEV (1963 a) points out that their evaluation and further use is hardly possible, owing to many regrettable conditions (differing methods and instruments, not satisfactorily detailed, accurate and consistent descriptions of measurements, etc.). In all this the fact may probably play a part that light and radiation measurements are very complicated both from practical-methodical and theoretical viewpoints. Radiation arriving at the surface of the earth is a complicated combined system consisting of several components, which breaks down into further subcomponents in the plant associations — as a consequence of absorption, reflection and dispersion. The work of GEIGER (1961), dealing with the microclimate, also analyses this, while the examinations of ANDERSON

(1964a, b, 1966) are directed towards the different kinds of radiation; TOOMING, ROSS and their co-workers study the meteorological, physical and mathematical side of the question, their school represents a significant theoretical line. The methodical handbook of ŠESTÁK, ČATSKÝ and JARVIS (1971) provides a survey of world literature on the units used in light and radiation examinations, a compilation of their terminology and a survey of the instruments which are on the market.

The works of HORVÁTH and KOLTAI (1960) deal with the examinations into light as a physiologic-ecological factor and point out the practical difficulties of research. FEKETE (1972) analyses the photosynthesis-related, production implications of light ecological examinations, representing it with ample literature.

The light-ecological conditions of natural foliage wood stands and mainly of beeches are dealt with in the work of SALISBURY, LAUSCHER and SCHWABL, NÄGELI, TRANQUILLINI (1960), ANDERSON (1964a, b; 1966), TRAPP (1938), EBER (1971; 1972), ALEKSEEV (1963b), GORYSINA (1969; 1974), etc.

Home light researches have been conducted for years in the oakwood at the Kossuth Lajos University of Sciences, Debrecen (NAGY, 1972).

One of the fundamental difficulties in radiation measurements of natural plant stands is the mosaic-like, spotted light-diffusion (sunlight and shade) over the floor, of the not entirely closed stands (EVANS, 1956; ZELLNIKER, 1969). Under clear conditions (for the importance of the actual weather conditions see ANDERSON, 1964a, b and ALEKSEEV 1963a) a part of the direct sunlight arrives through the diaphragms of the foliage into the floor of the forest, and distributing unevenly there forms sharply outlined spots of different light compositions and light intensities. Their measurement and further evaluation has not yet been solved.

Study target

Living creatures follow, with the rhythm of their life phenomena, the rhythmic changes occurring in their environment. One of the forms of manifestation of adjustment by plant associations to the seasonal changes of the climate is the occurrence of aspects. This is especially expressed in beechwoods. In the evolvement of the geophyton plant life form, the seasonal changes in light conditions are not indifferent. The light decrease in summer found by us on the floor of the forest (light-value of one or two magnitudes smaller than those on the leafless, spring floor of the forest) is one of the ecologically limiting factors of the species.

Man with his conscious activity in forest cultivation (the closed, monocultural growing of beeches, partial cutting, clear cutting) modifies the natural course of temporal dynamic of the forest, that is, the gradual reproduction,

and creates an artificial "rhythm", a life cycle (rotation period) of long duration. In the course of this activity, significant changes take place in the light conditions. The species of the underwood either adapt themselves to the changes by their ecological tolerance, or perish. The tracing of changes occurring in the light climate of a beechwood during a whole rotation period (some 140 years) is not possible in a lifetime. Therefore, in the course of the development of the forest, we chose three beechwood stands of different ages for the reproduction of the light effects on the undergrowth.

Our investigations attempted to acquire information, on the one hand, on the light effect that exerts influence upon the herbaceous layer in beechwoods, on the quantity of light endured by the plants during the spring (during their reproductive life cycle) and on the changes of light conditions during the later phases of the vegetative period. On the other hand, we examined the changes in light effects on the undergrowth occurring with the changes in the age of the beech forest; further, we examined at what time (in which vegetation period) the woods of the individual age period excel according to light intensity ("lighest" and "darkest" stands), at what time the light intensity differences, following from the differences in the age of the woods (resulting also in the differences of stand structures) are the most expressed.

Material and method

According to our aims outlined above, light measurements were made in 1974, during the whole vegetation period of three adjacent beechwoods of different ages and stand structures (the first one young, the second of middle age, the third old; see Figs 1—3). The measurements were carried out in the undergrowth, at the grasslayer (at a height of 50 cm). For estimating the quantity of light arriving at the top of the forest, we made measurements, parallel with those in the forest, on a nearby 300×600 m clearing, also at a height of 50 cm, beginning with the end of April.

On the basis of previous considerations, we marked the sampling area in the Mts. Pilis, in the range of the Vöröskő at the village of Tahi; (latitude 47°46′, 350 m a.s.l.). Owing to the cold and humid microclimate, there grows here an extensive extrazonal beechwood of a northern, valley bottom character; accordingly, we made transsects of identical expositions in the individual stands (1, 2, 3). During the sampling, we took to the extent of our possibilities, certain basic requirements into consideration, as for example the satisfactorily large number of measuring points, and the identical canopy structure of the various forest stands. One 64 m long transsect consisted of 32 pieces of 2×2 m squares. Light was measured in the middle of the square, at the same point, at every half minute (32 readings during 16 minutes per stand).

The measuring instruments used were: a JU 16 selenic-celled photoelectric lux-meter in the three forest stands, while in the clearing a PU 150 lux-meter. The instruments were calibrated and no correction was necessary during the year. In the clearing the receiving surface of the instrument was shaded. Thus in the clearing we obtained I_0 total diffuse light intensity values, and in the forest I absolute and $\frac{I}{I_0} \cdot 100$ relative "forest diffuse" light intensity values. Therefore we measured on the floor of the forest the light diffused by the forest (I) and compared it with the diffuse light measured in the clearing (I_0) (ANDERSON 1966).

In the light climate of forest plant stands diffuse light, its quantity, distribution and changes in space and time is of decisive importance. The fact that diffuse light comes to the forefront against the direct light is illustrated by the following data:

Fig. 1. The young experimental beechwood stand (Photo: T. Simon)

	20°	50° sunheight
cloudy (diffuse)	500 lux	6500 lux
clear (direct + diffuse)	230 lux	4800 lux

Under clear conditions, on the forest floor the direct sun-flecks were avoided in agreement with EVANS' method (1956). For, according to our measurements, in clear weather in the spring, at 30° sunheight, the light intensity differences between sunflecks and party shaded or shaded parts on the wood floor are 5—8-fold. We recorded the weather condition at every measurement, and also estimated the cloudy state. The character, distribution and quantity of light on clear, cloudless, or overcast, evenly or thinly, or more thickly clouded days are so different and incomparable that we always evaluated only similar data obtained during weather conditions corresponding to one

Fig. 2. The middle aged experimental beechwood stand (Photo: T. Simon)

another. Measurements taken in windly weather, or on days of cloud-drifts, were left out of further evaluations (ANDERSON, 1966).

In the wood stands and in the clearings, one measurement belonged to every 10° sunheight; the four workers, using stoppers, carried on the recording at identical, time moments synchronous.

In spring, at the time of exfoliation, the measurements were taken every 10 days, while later on every month. The daily data processing of some 800—1000 values was made by machines ODRA. Randomly arranged variance analysis (SVÁB, 1973) was used to check the efficiency of the three treatments (stands 1, 2, and 3).

The phenological conditions of the wood canopy and the undergrowth were under observation during the whole vegetation period, but these examinations, as well as those directed towards the light-ecophysiological adaptation of the species in the undergrowth, will be the subject of another paper.

Fig. 3. The old matured experimental beechwood stand (Photo: T. Simon)

The beechwood stands of the sampling area may be classified as unmixed, shrubless, semidry and fresh beechwood types (MAJER, 1968). The three stands, with a herbaceous undergrowth at the grasslayer, represent three different stages in the growth of the wood. The total coverage of the grasslayer species is of a 20% maximum, and the ground is covered with thick litter. The whole region is under regular forest culture.

1. Youngish stand, about 20 year old forest. The canopy is already satisfied, and it was partial cut in 1974. The foliage coverage is 10/10, the general trunk distance 2 m, the average diameter 5 cm at chest height, the general height 8 m. *Asperula odorata*, *Carex pilosa*, and *Melica uniflora* are characteristic of the grasslayer; there is no spring aspect.
2. Middle-aged stand, 40—50 year old forest. Foliage coverage 8/10, general trunk distance 6—8 m, general diameter 16 cm at chest height, general height 25 m. The grasslayer is poor, with a spring aspect of *Dentaria bulbifera*, followed by *Asperula odorata*, *Viola alba*, and *Carex pilosa*.
3. Old, matured stand, older than 120 years. Foliage coverage 9/10, general trunk distance 12 m, general diameter 44 cm at chest height, general height above 30 m. Boles standing apart, with an extensive lateral branchy canopy. Grasslayer rich, best among the three stands. An expressed *Dentaria bulbifera* aspect is followed by *Carex pilosa*, *Melica uniflora*, *Asperula odorata*, *Lamium galeobdolon*, etc. There are a great number of beech seedlings.

The time of exfoliation shifts in time with the age of the forest. The younger stand buds, and produces it foliage earlier than the older ones. It is characteristic of all three stands that the ecotypes of beech budding earlier and later occur together.

Results and discussion

Our measurements were made between 3 April and 20 November, 1974, during the whole vegetative period. During this time, the duration of days changed between 9 and 16 hours, while the daily maximum of sunheight changed between 20° and 60° (in a 10° breakdown).

The light conditions on the floor of the three beechwood stands (1, 2, 3) and those on clearing (4) are summarized in Table 1. The figures given in the cells of the Table are the average of light intensity values originating from 32 measurements related to light arriving at the floor of the forest I, and in the clearing of the forest, I_0. These light conditions occur on the floor of the forest, and from them inferences can be drawn on the light ecological conditions of the undergrowth.

Table 1

Light intensity means related to one sampling square (I), according to sunheight categories and the daily means (10^2 lux)
(a) age-groups: (1) young, (2) middle-age, (3) old stand, (4) clearing (b) sunheight
Symbols of the weather situation: ○ clear, cloudless sky; ⌀ clear, sky with cloud-drift; □ overcast, thin clouds; ⊠ overcast, thick clouds

	b 10°	20°	30°	40°	50°	60°	50°	40°	30°	20°	10°	Average
IV. 3. a	○	○	○	○				○	○	○		
1.	24.08	54.90	100.53	111.53				79.33	53.21	42.56		66.59
2.	25.32	82.50	74.12	92.53				87.80	51.78	27.18		63.03
3.	34.68	76.96	101.90	106.30				67.66	30.75	18.53		62.40
IV. 12.	⊠	⊠	⊠	⊠	⊠			⊠	⊠	⊠	⊠	
1.	7.35	20.18	18.90	38.37	22.50			16.27	11.43	23.18	15.93	19.34
2.	11.84	30.62	42.68	43.84	33.12			17.81	24.50	21.25	9.32	26.11
3.	10.81	20.57	24.62	27.15	20.23			9.68	15.81	12.56	9.51	16.77
IV. 23.	○	○	○		□		□	□	○	○		
1.	5.95	8.07	13.51		18.80		19.82	19.51	13.62	8.44		13.46
2.	12.13	24.26	33.96		28.33		31.94	23.64	18.93	11.24		23.05
3.	10.78	18.64	17.96		14.04		15.28	9.88	6.99	5.10		12.33
4.	51.12	64.93	92.25		147.37		208.43	128.81	117.31	100.75		114.81
V. 15.		○	○	○	○	○	⊠	⊠	⊠	⊠		
1.		2.64	3.86	4.06	3.74	5.74	5.12	5.49	3.45	3.03		4.12
2.		4.48	5.56	6.07	4.55	4.13	3.08	4.74	3.70	2.55		4.32
3.		5.22	5.71	6.92	4.52	4.41	2.03	4.37	3.11	2.91		4.35
4.		113.62	134.50	161.18	166.13	136.43	129.31	186.12	152.62	115.43		143.92
VI. 20.			○	○	⌀	○	○	⌀	⌀			
1.			2.59	3.85	4.49	4.30	4.69	4.00	2.44			3.76
3.			4.23	5.18	4.64	3.68	2.96	2.13	1.24			3.43

4.			136.40	177.56	163.62	162.28	155.15	164.56	106.84		152.34
VII. 23.			□	⊠	⌀	⊠	○	□	□	□	
1.			3.84	2.63	7.23	4.14	8.50	1.37	4.21	1.13	4.13
2.			5.36	3.56	6.98	3.82	5.38	1.36	3.53	1.05	3.88
3.			6.00	3.80	7.00	3.84	5.81	1.65	2.88	1.23	4.03
4.			325.36	241.87	184.21	257.50	252.90	105.90		104.90	210.37
IX. 17.		○	○	○				○	○	○	
1.		4.32	5.14	5.97				5.32	5.55	4.18	5.08
2.		2.81	2.85	3.03				2.71	2.57	1.82	2.63
3.		2.91	2.82	2.59				2.24	1.83	1.36	2.29
4.		70.60	103.81	139.62				127.75	100.75	65.62	101.35
XI. 20.		□								□	
1.		68.62								60.28	64.45
2.		58.68								38.31	48.50
3.		47.87								40.15	44.01
4.		93.68								115.12	104.40

By a comparison between light values I and I_0 appearing in the column of average in Table 1, it can be stated that in the beechwood of our study merely 50% of the total light arrives at the forest floor (without consideration to age groups) in the leafless state 20 Nov. Therefore half of the light is absorbed by the trunk-branch zone. This is a surprisingly low value if related to oakwoods; GORYSINA (1969) gives 45—90% for oakforests. In the period of exfoliation it is 14% of the total light that arrives at the beechwood floor (23 April); at the time of the full foliage (from the middle of May to the end of September), the relative light condition on the beechwood floor is not consistent; in May (15th) and September (17th) it is equally 3%, while in June (20th) and July (23th) it does not reach the 2%-value. The quantity of light transmitted or absorbed by leaf-surfaces of the same size varies with the thickness of the leaves.

Distributions in the relative light conditions of the beechwood floors of different age, $\frac{I}{I_0} \cdot 100$, are as follows:

	1.	2.	3.
Spring, April and May (exfoliation)	10.8	20.2	12.0
Summer, June—September (full foliage)	3.1	2.3	2.2
(but the yearly minimum)	(1.3)	(1.5)	(1.6)
Autumn, November (wholly leafless)	61.9	45.9	42.1

Compared to oakwoods (GORYSINA, 1969), the leafless beechwood floor is characterized not only by low relative light conditions, but also by its narrower extent (40—60%).

As regards the yearly course, the most fundamental regularity in the radiation and light conditions of deciduous forests is that in the vegetative period the light period of early springtime is followed by the shadeperiod of summer (EGLE, 1937; TRANQUILLINI, 1960). Following the more detailed division by GORYSINA (1974), and according to our experiences, the light conditions of the beechwood in the vegetative period may be grouped as follows:

I. Spring sunlight phase
II. Transitional phase (the period of exfoliation)
III. Summer phase poor in light
IV. Autumn rise

I. In springtime, an 8—10-fold summer illumination arrives at the beechwood floor, while only 5—8-fold in oakwood (GORYSINA, 1974).

Table 2

Variance analysis of the absolute light-intensity values, I

(a) date; (b) sunheight. First row in one cell: total; second row: treatment; third row: error; frist column: SQ; second column: FG; third column: MQ — Weather situation in place of all MQ (see Table 1) Significance levels: * $P < 5\%$; ** $P < 1\%$; *** $P < 0.1\%$

a \ b	10°			20°			30°			40°			50°			60°			50°			40°			30°			20°			10°		
IV. 3.	43.6	95	○	286.7	95	○	934.0	95	○	1253.8	89	○										758.0	89	○	181.3	95	○	145.7	95	○			
	22.7	2	11.4***	136.4	2	68.2***	156.9	2	78.5***	57.8	2	28.9										61.3	2	30.7*	101.3	2	50.6***	95.0	2	47.5***			
	20.9	93	0.22	150.3	93	1.61	777.1	93	8.35	1196.1	87	13.74										696.6	87	8.01	80.0	93	0.90	50.7	93	0.54			
IV. 12.	570.3	95	⊠	38.4	95	⊠	138.8	95	⊠	103.7	95	⊠	63.3	95	⊠							7.5	32	⊠	37.7	95	⊠	45.4	95	⊠	24.0	95	⊠
	353.0	2	167.5***	22.4	2	11.2***	98.6	2	49.3***	46.3	2	23.2***	30.3	2	15.2***							4.1	2	2.1***	28.3	2	14.1***	20.5	2	10.2***	9.1	2	4.5***
	217.2	93	2.33	15.9	93	0.20	40.2	93	0.43	57.4	93	0.61	33.0	93	0.35							3.4	30	0.11	9.4	93	0.10	24.9	93	0.30	14.9	93	0.20
IV. 23.	2544.9	95	○	142.0	89	○	114.0	89	○				39.9	71	□				67.7	77	□	57.4	77	□	49.4	95	○	1739.7	95	○			
	674.7	2	334.7***	40.6	2	20.3***	59.6	2	29.8***				25.4	2	12.7***				38.6	2	19.3***	24.4	2	12.2***	22.9	2	11.5***	605.4	2	302.7***			
	1870.2	93	20.10	101.5	87	1.16	54.5	87	0.62				14.5	69	0.21				29.1	75	0.38	33.1	75	0.44	26.5	93	0.28	1134.3	93	12.19			
V. 15.				287.0	89	○	271.3	89	○	246.7	59	○	298.1	89	○	215.8	89	○	398.6	89	⊠	194.8	89	⊠	108.9	89	⊠	94.6	89	⊠			
				106.0	2	53.0***	63.3	2	31.7***	86.3	2	43.1***	12.7	2	6.4	44.7	2	22.3***	148.4	2	7.42***	19.4	2	9.7*	7.4	2	3.7*	3.8	2	1.9			
				181.0	87	2.08	208.0	87	2.39	160.4	57	2.81	285.4	87	3.28	171.2	87	1.96	250.2	87	2.87	175.3	87	2.01	101.5	87	1.16	90.8	87	1.04			
VI. 20.							99.8	59	○	82.1	43	○	89.7	57	○	85.0	41	○	192.9	55	○	203.3	63	⌀	71.0	63	⌀						
							40.2	1	40.2***	19.4	1	19.4***	0.3	1	0.3	4.1	1	4.1	41.1	1	41.1***	55.9	1	55.9***	23.2	1	23.2***						
							59.6	58	1.02	62.8	42	1.49	89.4	56	1.59	80.9	40	2.02	151.8	54	2.81	147.4	62	2.37	47.9	62	0.77						
VII. 23.							190.0	65	□	129.3	89	⊠	489.4	86	⌀	199.9	95	⊠	469.3	68	○	20.4	95	□	261.5	89	□	17.2	95	□			
							54.5	2	27.3***	23.1	2	11.5***	1.0	2	0.5	2.0	2	1.0	131.9	2	66.0***	1.8	2	0.9*	27.1	2	13.5**	0.5	2	0.2			
							135.4	63	2.14	106.2	87	1.22	488.5	84	5.81	197.8	93	2.12	337.4	66	5.11	18.7	93	0.20	234.4	87	2.69	16.7	93	0.17			
IX. 17.				113.7	95	○	202.5	95	○	299.3	95	○										320.2	95	○	331.9	95	○	235.7	95	○			
				45.0	2	22.5***	113.5	2	56.7***	208.7	2	104.3***										202.1	2	101.0***	247.5	2	123.8***	157.8	2	78.9***			
				68.7	93	0.73	89.1	93	0.95	90.7	93	0.97										118.2	93	1.27	84.4	93	0.90	77.9	93	0.83			
XI. 20.				87.3	95	□																						103.6	95	□			
				67.3	2	33.7***																						95.0	2	47.5***			
				19.9	93	0.21																						8.6	93	0.09			

Table 3

Variance analysis of the relative light intensity values $\frac{I}{I_0} \cdot 100$. (Symbols as before in Table 2)

a \ b	10°			20°			30°			40°			50°			60°			50°			40°			30°			20°		
IV. 23.	99.6	95	○	242.1	89	○	188.9	92	○				42.4	95	□				24.8	95	□	48.1	95	□	30.8	95	○	1314.3	95	○
	25.9	2	13.0***	75.5	2	37.8***	85.3	2	42.7***				22.2	2	11.1***				13.2	2	6.6***	21.4	2	10.7***	16.1	2	8.1***	611.8	2	305.9***
	73.7	93	0.79	166.5	87	1.91	103.7	90	1.15				20.2	93	0.21				11.6	93	0.12	26.7	93	0.28	14.7	93	0.15	702.5	93	7.55
V. 15.				227.7	95	○	204.1	95	○	209.5	95	○	156.8	89	○	179.9	95	○	243.5	95	⊠	51.6	89	⊠	34.1	89	⊠	57.1	89	⊠
				80.3	2	40.1***	36.0	2	18.0***	38.8	2	19.4***	1.1	2	0.6	42.5	2	21.3***	43.1	2	21.6***	5.4	2	2.7**	1.7	2	0.8*	4.6	2	2.3*
				147.4	93	1.58	168.1	93	1.80	170.8	93	1.83	155.7	87	1.78	137.4	93	1.47	200.4	93	2.15	46.2	87	0.53	32.5	87	0.37	52.5	87	0.60
VI. 20.							74.1	63	○	62.5	43	○	67.7	63	⌀	32.1	41	○	108.1	63	○	60.6	63	⌀	64.2	63	⌀			
							22.5	1	22.5***	2.1	1	2.1	0.0	1	0.0	1.4	1	1.4	20.1	1	20.1***	18.5	1	18.5***	19.7	1	19.7***			
							51.5	62	0.83	60.4	42	1.43	67.7	62	1.10	30.7	40	0.76	88.0	62	1.41	42.1	62	0.67	44.5	62	0.71			
VII. 23.							22.7	65	□	23.2	95	⊠	130.2	95	⌀	29.6	95	⊠	97.7	95	○	23.1	95	□				18.5	95	□
							5.4	2	2.7***	3.3	2	1.6***	0.04	2	0.02	0.2	2	0.1	9.0	2	4.5*	1.6	2	0.8*				0.5	2	0.3
							17.2	63	0.27	20.0	93	0.21	130.1	93	1.39	29.4	93	0.31	88.8	93	0.95	21.5	93	0.23				18.0	93	0.19
IX. 17.				201.1	95	○	202.4	95	○	153.4	95	○										205.1	95	○	361.6	95	○	523.2	95	○
				68.6	2	34.3***	106.3	2	53.1***	109.3	2	54.6***										126.3	2	63.2***	252.2	2	126.1***	337.7	2	168.9***
				132.5	93	1.42	96.1	93	1.03	44.1	93	0.47										78.7	93	0.84	109.4	93	1.17	185.5	93	1.99
XI. 20.				250.7	95	□																						79.7	95	□
				80.0	2	40.0***																						71.8	2	35.9***
				170.7	93	1.83																						7.9	93	0.08

Table 4

Significant differences in the means of absolute light intensities I in the three stands

(a) date; (b) sunheight; (1) young; (2) middle-age; (3) old stand. Within one cell the light average on the main diagonal; right-side semimatrix: their differences; left-side semimatrix; their significance levels: * $P < 5\%$; ** $P < 1\%$; *** $P < 0.1\%$

a \ b	10°			20°			30°			40°			50°			60°			50°			40°			30			20°			10°		
	1.	2.	3.	1.	2.	3.	1.	2.	3.	1.	2.	3.	1.	2.	3.	1.	2.	3.	1.	2.	3.	1.	2.	3.	1.	2.	3.	1.	2.	3.	1.	2.	3.
IV. 3. 1.	2.40	0.13	1.09	5.49	2.76	2.20	10.05	2.64	0.14													7.93	0.85	1.17	5.32	0.15	2.25	4.25	1.54	2.40			
2.	—	2.53	0.96	***	8.25	0.56	***	7.41	2.78													—	8.78	2.02	—	5.17	2.10	***	2.71	0.86			
3.	***	***	3.49	***	—	7.69	—	***	10.19													—	**	6.76	***	***	3.07	***	***	1.85			
IV. 12. 1.	7.35	4.49	3.46	2.01	1.05	0.04	1.89	2.37	0.57	3.83	0.55	1.12	2.25	1.06	0.23							1.62	0.16	0.66	1.14	1.31	0.44	2.31	0.19	1.06	1.59	0.66	0.64
2.	***	11.84	1.03	***	3.06	1.01	***	4.26	1.80	**	4.38	1.67	***	3.31	1.29							—	1.78	0.82	***	2.45	0.87	—	2.12	0.87	***	0.93	0.02
3.	***	**	10.81	—	***	2.05	***	***	2.46	***	***	2.71	—	***	2.02							***	***	0.96	***	***	1.58	***	***	1.25	***	—	0.95
IV. 23. 1.	5.95	6.18	4.83	0.80	1.62	1.06	1.35	2.04	0.44				1.88	0.95	0.48				1.98	1.21	0.46	1.95	0.41	0.97	1.36	0.53	0.67	8.43	2.78	3.33			
2.	***	12.13	1.35	***	2.42	0.56	***	3.39	1.60				***	2.83	1.43				***	3.19	1.67	*	2.36	1.38	***	1.89	1.20	**	11.21	6.11			
3.	—	***	10.78	***	*	1.86	*	***	1.79				***	***	1.40				**	***	1.52	***	***	0.98	***	***	0.69	***	***	5.10			
V. 15. 1.				2.64	1.84	2.58	3.86	1.70	1.85	4.06	2.01	2.86				5.74	1.61	1.33	5.12	2.04	3.09	5.49	0.75	1.12	3.45	0.25	0.32						
2.				***	4.48	0.74	***	5.56	0.15	***	6.07	0.85				***	4.13	0.28	***	3.08	1.05	*	4.74	0.37	—	3.70	0.57						
3.				***	*	5.22	***	—	5.71	***	—	6.92				***	—	4.41	***	*	2.03	**	—	4.37	—	*	3.13						
VI. 20. 1.							2.59		1.64	3.28		1.38	4.49		0.15	4.30		0.62	4.69		1.73	4.00		1.87	2.44		1.20						
3.							***		4.23	***		4.66	—		4.64	—		3.68	***		2.96	***		2.13	***		1.24						
VII. 23. 1.							3.84	1.52	2.16	2.63	0.93	1.17							8.50	3.12	2.69	1.37	0.01	0.28	4.21	0.68	1.33	1.13	0.08	0.10			
2.							***	5.36	0.64	**	3.56	0.24							***	5.38	0.43	—	1.36	0.29	—	3.53	0.65	—	1.05	0.18			
3.							***	—	6.00	***	—	3.80							***	—	5.81	**	**	1.65	**	—	2.88	—	—	1.23			
IX. 17. 1.				4.32	1.51	1.41	5.14	2.29	2.28	5.97	2.94	3.28										5.32	2.61	3.08	5.55	2.98	3.68	4.18	2.36	2.98			
2.				***	2.81	0.10	***	2.85	0.03	***	3.03	0.34										***	2.71	0.47	***	2.57	0.74	***	1.82	0.62			
3.				***	—	2.91	***	—	2.82	***	—	2.69										***	—	2.24	***	***	1.83	***	*	1.20			
XI. 20. 1.				6.86	1.00	2.08																						6.02	2.19	2.01			
2.				***	5.86	1.08																						***	3.83	0.17			
3.				***	***	4.78																						***	*	4.01			

Table 5

Significant differences in the means of the relative illuminations $\frac{I}{I_0} \cdot 100$ *in the three age groups* (Symbols as before in Table 4)

a \ b	10°			20°			30°			40°			50°			60°			50°			40°			30°			20°		
	1.	2.	3.	1.	2.	3.	1.	2.	3.	1.	2.	3.	1.	2.	3.	1.	2.	3.	1.	2.	3.	1.	2.	3.	1.	2.	3.	1.	2.	3.
IV. 23. 1.	1.15	1.22	0.95	1.29	2.11	1.68	1.45	2.20	0.54				1.25	0.90	0.10				0.96	0.67	0.19	1.26	0.65	0.53	1.13	0.47	0.54	7.96	3.33	2.86
2.	***	2.37	0.27	***	3.40	0.43	***	3.65	1.66				***	2.15	1.00				***	1.63	0.86	***	1.91	1.18	***	1.60	1.01	***	11.29	6.19
3.	***	—	2.10	***	—	2.97	*	***	1.99				—	***	1.15				*	***	0.77	***	***	0.73	***	***	0.59	***	***	5.10
V. 15. 1.				2.46	1.73	2.10	3.06	1.31	1.28	3.26	0.51	1.02				4.53	1.52	1.25	4.03	1.53	1.28	2.97	0.39	0.61				2.67	0.50	0.03
2.				***	4.19	0.37	***	4.37	0.03	—	2.75	1.53				***	3.01	0.27	***	2.50	0.25	*	2.58	0.22				*	2.17	0.47
3.				***	—	4.56	***	—	4.34	**	***	4.28				***	—	3.28	***	—	2.75	**	—	2.36				—	*	2.64
VI. 20. 1.							2.05		1.19	2.60		0.43				2.59		0.36	2.89		1.12	2.37		0.13	2.28		1.11			
3.							***		3.24	—		3.11				—		2.23	***		1.77	—		2.24	***		1.17			
VII. 23. 1.							1.19	0.46	0.63	1.21	0.29	0.44							2.75	0.65	0.66	1.31	0.01	0.25						
2.							**	1.65	0.17	*	1.50	0.15							**	2.10	0.01	—	1.30	0.26						
3.							***	—	1.82	***	—	1.65							**	—	2.09	*	*	1.56						
IX. 17. 1.				5.86	1.86	1.72	4.99	2.21	2.26	4.26	2.09	2.40										4.36	2.24	2.60	5.59	3.03	3.74	6.21	3.55	4.46
2.				***	4.00	0.14	***	2.78	0.05	***	2.17	0.31										***	2.12	0.36	***	2.56	0.71	***	2.66	0.91
3.				***	—	4.14	***	—	2.73	***	—	1.86										***	—	1.76	***	**	1.85	***	**	1.75
XI. 20. 1.				7.33	1.05	2.21																						5.23	1.93	1.75
2.				**	6.28	1.16																						***	3.30	0.18
3.				***	***	5.12																						***	**	3.48

II. This phase is not sharply delimited from the preceding and the succeeding ones. The length and character of this phase is the function of the weather conditions of the given year; the unevenness of the latter can modify it to a great extent; in 1974, for example the second half of March and April were very mild and warm, the beech buds burst one month. It is common knowledge that the two ecotypes of *Fagus silvatica* do not produce leaves at thesame time; in the early warmth the "early beech" ecotype individuals came into leaf early, then, in the coldness that followed, the exfoliation slowed down and reached its full state only by the middle of May. Thus the transitional phase was considerably protracted. This phase is the period of foliage development; the light conditions of the floor of the three stands changed extensively during this time. As against the spring period, substantial re-arrangements took place in the light conditions (the lighest, the darkest) of the individual stands. By the end of this phase light conditions develop which become constant during the summer. According to the Tables, most of the significant differences occurred in this period, frequently in the case of all three stands.

III. The light conditions of the summer phase poor in light, lag by one order of magnitude behind those of the spring and the autumn (Table 1). Light conditions on the forest floor showed a tolerable consistency (Tables 2 and 3); concerning the daily course, this period is of the most homogeneous light diffusion at the grasslayer, and also the differences according to age groups are — relatively — less frequent (Tables 4 and 5). This is one of the most important results of the examinations, namely, that the difference between the various age groups is great in the transitional vegetative period; it is greater than at the time of the fully developed foliage.

IV. This phase is represented by the late autumn measurement (when, owing to a low sunposition only the 20° altitude could be measured by our method). The daily average of the light intensity is similar to that recorded in early spring.

While Table 2, dealing with the absolute light values of I displays the variability concerning the undergrowth of the three forest stands, Table 3, constructed on the basis of $\frac{I}{I_0} \cdot 100$ relative light values, is characteristic of the optical features of the forest stands; at the same time, it expresses the light received by the undergrowth less concretely than the absolute illumination. The canopies of differing structure ("treatments" 1, 2, and 3) do not economize identically with the same quantity of light I_0. Therefore, a comparison between their absolute and relative values is not wholly identical either (Tables 2—3 and 4—5). In summer, during noon time hours and at great sunlight (June, July, 40—50—60°) the differences between the individual age groups, deriving optical structure, are smaller (Table 3., they

develop on fewer occasions) than the differences in the values of light actually received on the forest floor (Table 2). At the same time, the differences expressing the differing optical structure before and after the exfoliating period are greater than those of the actual light intensity in the undergrowth of the three stands.

Concerning the absolute light intensity values of I, the differences are the most expressed in the morning and forenoon hours, while — under the effect of greater sunheights — the means tend to overlap. The best example of this happened on 20 June, when at 60° not even the young and old stands representing the two extreme age groups were significantly different from each other. Measurements after the noontime hours also tend more towards a decrease in the differences, for — as a result of local configurations of the terrain — the sun sinks behind the mountains relatively early; thus, in the afternoon measurements it is rather the diffuse radiation that comes to the forefront, even in clear weather, which — as is well known — tends to resolve the differences in light intensity. An extreme example of this was on 23 July, at 20° (afternoon), when no significant difference occurred in any of the three stands. Therefore, the measurements belonging to forenoon sunheights of 10, 20, 30, 40° are more informative. Our remark made above refers equally to the leafless spring and autumn and to the exfoliated summer states. The asymmetry of such curves of the daily courses is partly a result of the local configurations of the terrain.

In the formation of the light conditions according to seasons we found that in spring the middle-age group was lighter than the other two, while in summer and autumn the young stand proved to be lighter (Fig. 4).

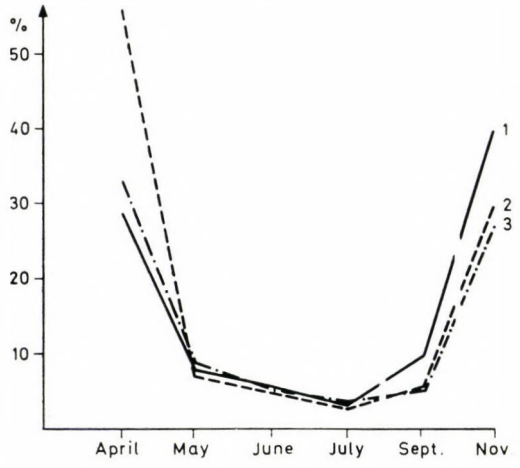

Fig. 4. Relative light intensity conditions on the forest floor of the three stands of different age-groups in the vegetation period. 1: young stand; 2: middle-age stand; 3: old stand

The relative light intensity of the undergrowth of the three age groups, in the vegetative period, $\frac{I}{I_0} \cdot 100$, is shown in Fig. 4. In summer, the courses of the curves approach one another, that the differences detectable in spring and autumn are not significant in the case of any of the stand pairs.

In spring, the smaller similarity appeared between the young and old stands, while the more significant summer correspondence was detected between the stands of middle- and old-age groups. We have observed that prior to exfoliation, the trunks and branches of the young and old stands may cause similar light conditions as well in a stand of densely standing young trees with slender trunks and sparse canopy as in a stand of older ones with thick boles and widely ramifying branches, and that the trunks and branches decrease more drasticaly the light arriving at the floor of the forest than in the case of a stand of trees of the middle-age group with an intermediate trunk-branch structure. The stand of middle-age group appeared to be the most abundant in light prior to attaining complete foliage. Concerning the relation between the young and old woods, it might have been expected, in view of their habit, that in the young stand the very densely spaced trunks would hinder the arrival of light at the forest floor; the fact that the floor of the young forest is not definitely poor in light during spring and autumn follows from the young trees being short, with thin branches and a small canopy.

In full summer foliage on the other hand, the young forest, producing a vertically less discrete foliage composed of smaller, thinner, and brighter leaves, can be characterized by higher light values at the grass layer during the season. The relative abundance of light during in the young stand may have an influence on the survival of undergrowth species with a long vegetative period (species in general of the hemicryptophyton life form). Our finding that the rate of geophytons in the undergrowth of the young forest is much smaller, and that there is no definite spring aspect, is in agreement with those said above.

The relatively greater difference in light intensity (deriving mainly from differences in trunk distance) between the old and middle-age group stands during springtime cannot be detected in summer, indeed the light intensity difference in the old and middle-age stand floors is not even significant in 50% of the measurements. It can inferred therefore that in the leafless state the trunkbranch structure is decisive; in the leafy state their effect is much smaller; concerning foliage-structure, the old and the middle age stands are nearer to each other, the young stand differs from them; concerning trunk-branch structure, the old and the young stands show similarity.

Summary

During the whole vegetation period in 1974, light intensity measurements were made on the floor of beech stands of three different age-groups, and on a nearby clearing. Our results can be summarized as follows:

1. Beechwoods in the leafy state decrease the light received on top: in summer by two orders of magnitude, while in spring and autumn by one order of magnitude.

2. On the beechwood floor, the difference in light intensity between the leafy and leafless states is only of one order of magnitude, and this follows from the leafless state being relatively poor in light.

3. During the vegatative period, in spring and autumn (at the time of the two incompletely leafy states), light intensity differences between the age-groups are characteristic, while in summer, in the leafy state, the differences become partically indistinct, in light conditions on the forest floor.

In spring, the light conditions in the young and the old stands are similar to each other, both woods are "dark"; in summer and autumn, the middle-age and old-age stands show greater similarity.

4. The character of the trunk-branch structure in the young and the old stands in spring lead to the formation of similar light conditions; the foliage structure causes similar light conditions in the middle-age and old-age stands.

5. Until the leafy period, the young stand is relatively darker, then relatively lighter; the more uniform light conditions are assumably also responsible, together with other dynamical processes, for the absence of the geophyton aspect.

6. During the whole vegetation period the daily courses of light intensity are not symmetric; this is attributable to the effect of the local configurations of terraine. The morning and forenoon readings (at sunheights of 10, 20, 30, 40°) represent the light intensity differences following from the diverse optical structures of the three stands. These readings are more informative in comparison with the noon and afternoon readings.

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CHANGES IN THE AREA AND WEIGHT OF LIGHT- AND SHADE-ADAPTED LEAVES AND SHOOTS OF QUERCUS PETRAEA AND QUERCUS CERRIS IN A HUNGARIAN OAK FOREST ECOSYSTEM*

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The present paper deals with the growths of light- and shade-adapted shoots and leaves as expressed in area and dry weight of the two tree species, *Quercus petraea* and *Qu. cerris*, both study objects of the Síkfőkút Project. Biweekly or mensually collected data during the 1973 vegetation period were based on optical planimetrical and dry weight measurements which permitted to trace the development of leaf and shoot production and the loss of material due to caterpillar feeding. Since the number of sampled leaves were known, the obtained data could be transposed per hectare.

Research in the field of ecosystems has always emphasized the importance of comprehensive investigation of green plant parts active in the photosynthetic process. Annual analyses of leaves and shoots most frequently focus on areal and weight measurements based on a suitable number of samples, allowing inferences on the development of leaf and shoot production respectively. But the same measurements point to the various growth parameters descriptive of the growth of individual green parts and to the interrelationship between the photosynthetic apparatus and production (BLACKMAN, 1919; BRIGGS—KIDD—WEST, 1920; WATSON, 1952; COOMBE, 1960; JARVIS, 1963; WILLIAMS, 1964; BLACKMAN, 1968; KVĚT—ONDOK—NEČAS—JARVIS, 1971 and others). In this study, the authors publish the results obtained during their research on leaves and shoots in the climate zonal *Quercetum petraeae-cerris* forest, near Eger, on the hilly land between the Great Hungarian Plain and the North Central Mountain Range of Hungary. The woodland was assigned to be the model of investigation (Síkfőkút Project), a part of the research programme "Man and Biosphere" (see JAKUCS, 1973; JAKUCS—HORVÁTH—KÁRÁSZ, 1975, B. PAPP, 1975, et al.). Measurements of area and weight were taken simultaneously on light- and shade-adapted shoots of the two dominant tree species. Investigations also included the temporal changes in site of whole leaves and of those damaged by caterpillars.

* "Síkfőkút Project" No. 18

Sampling

The principles governing the sampling procedure was planned to have the data representating the entire forest of a rather homogeneous appearance. Three sample trees have been selected from each of the two species (each tree being 65 years old, of similar habit and of similar location within the environment, etc.). Sampling was made on ten occasions during the vegetation period. Ten shoots were gathered from the upperouter part of the crown (light-adapted shoots) and ten shoots from the lowerinner part of the crown (shade-adapted shoots). Since the majority of the single shoots had 5 to 9 leaves, each sampling yielded 120 shoots, i.e. 800 to 900 leaves.

Material and method

The samples were grouped according to trees and light levels. The shoots were numbered, then the length of the shoot axis and the diameter at its middle measured, finally the number of leaves belonging to each shoot counted. The material was preserved in the pressed state.

Leaf area measurements

According to international usage, the characterization of the assimilating capacity of the leaf is based not on the entire leaf surface; it suffices to present the measurements of only one side (the area) of the leaf. (CARLISLE—BROWN—WHITE, 1966). Leaf area was measured by electric optical planimeter. The device has been designed for this specific purpose (CZELLÁR and B. PAPP, 1975). Measurement precision is $\pm 1\%$.

Measurement of the damaged leaf area

By the end of spring and the beginning of summer extensive caterpillar feeding could be observed in the forset (see Fig. 1). Calculation of the absent area was partly necessary to guarantee valid growth analysis and partly to estimate the area and weight of green assimilating organs already nonexistent.

Calculations were based on the correlations between leaf length and leaf area, leaf width and leaf area, length times width and area (see e.g. CARLISLE—BROWN—WHITE, 1966; KUBIČEK, 1971). In the case of both whole and damaged leaves area measurements were done parallel with leaf width and leaf length measurements as well. The whole leaf area of damaged leaves was computed by standard linear regression equations utilizing the measured data pairs. The obtained data were evaluated by the Computer Centre of the Kossuth Lajos

Fig. 1. Moderately damaged leaves on the shoots of *Quercus petraea* (photo: M. SZABÓ)

University, Debrecen. With respect to each category, equations expressing the closest relations (length times width—area) were applied to calculate the whole area of the damaged leaves. In some instances, were a parameter owing to caterpillar feeding was not available, we applied the equation pertinent to the measurable datum.*

Determination of the shoot area

Based on the measured length and diameter, we calculated the cylindrical surface area by the formula $2r\pi \cdot$ length.

Weight measurements and the determination of the original weight of the damaged leaves

The material was desiccated at 85°C for 48 hrs, then measured. In order to be able to reconstruct the original weight of the damaged leaves first the

* It should be remarked that in order to obtain more concise values when computing regression equations close attention had been paid to the degree of development of the individual leaves on the various shoots, with reference to the light- and shade-adapted leaves of the two tree species. Accordingly, the leaves were grouped, counting from the shoot apex, into the groups 1—3, 4—6, 7—9, 10—18. Preliminary calculations gave significant differences between all groups.

weight of an area of 1 cm² was figured. With the aid of this calculation the weight of the sound leaf area for each leaf could be determined by the regression equation as well as the weight of the entire set of leaves produced on one shoot.

Results and discussion

Seasonal changes in the average leaf area and weight of the reconstructed as well as of the damaged leaves for both oak species with respect to different light levels are given on Table 1 and illustrated in Fig. 2. Data displaying areal and weight variations of medium developed shoots (the mean of 30 shoots per

Table 1

Seasonal changes in the mean value of whole reconstructed and damaged leaf areas and weights of Quercus petraea and Quercus cerris in 1973

	Area in cm²				Weight in g			
	light		shade		light		shade	
	whole	caterpillar damaged	whole	caterpillar damaged	whole	caterpillar damaged	whole	caterpillar damaged
Qu. p.								
Apr. 18	2.25	—	3.13	—	0.0191	—	0.0202	—
May 4	17.93	16.07	30.50	27.90	0.0877	0.0863	0.1065	0.0964
10	24.72	17.83	27.26	22.41	0.1393	0.0975	0.1234	0.1020
24	26.05	21.62	35.61	32.08	0.1967	0.1630	0.1789	0.1581
June 13	22.70	15.42	29.99	23.67	0.2241	0.1515	0.2061	0.1806
27	20.33	15.06	30.71	26.27	0.2155	0.1573	0.2158	0.1834
July 27	21.24	16.49	28.84	22.26	0.2454	0.1914	0.2324	0.1775
Aug. 23	20.49	16.98	28.96	24.14	0.2207	0.1852	0.2004	0.1662
Sept. 26	19.47	15.43	28.86	22.66	0.2297	0.1838	0.2486	0.1890
Oct. 17	25.72	19.64	26.69	23.67	0.2578	0.1964	0.1743	0.1558
Qu. c.								
May 4	2.23	0.58	2.23	0.58	0.0172	0.0043	0.0172	0.0043
10	8.21	7.35	11.23	8.13	0.0586	0.0487	0.0520	0.0379
24	13.64	11.82	17.43	15.87	0.0925	0.0820	0.0931	0.0848
June 13	14.23	13.41	19.23	14.87	0.1298	0.1225	0.1211	0.0937
27	13.33	11.75	16.25	13.33	0.1523	0.1281	0.1042	0.0850
July 27	13.36	10.04	20.04	18.83	0.1684	0.1260	0.1338	0.1254
Aug. 23	13.50	11.37	18.04	14.47	0.1672	0.1411	0.1406	0.1136
Sept. 26	11.85	9.31	18.38	13.89	0.1482	0.1171	0.1417	0.1080
Oct. 17	16.16	13.02	18.89	14.62	0.1559	0.1253	0.1236	0.0974

tree) occurring during a given period are shown on Table 2 and illustrated in Fig. 3. The area of a single shoot represents the sum of the calculated area of the shoot axis and of the entire set of reconstructed leaves. The weight of the shoot equals the dry weight of the shoot axis and the dry weight of the sound leaf area.

Development of the area

The data unambiguously indicate that the area of the shade-adapted leaves is significantly larger than that of the light-adapted leaves. The primary cause is presumably also the inhibitive action of the light exerted on the leaves exposed to the more intense and direct radiation in the upper levels.

Table 2

Seasonal changes in the mean value of reconstructed area and weight of light- and shade-adapted shoots of Quercus petraea and Quercus cerris and the percentual extent of caterpillar induced damage calculated for shoot leaves in 1973

	Are in cm^2		Weight in g		Extent of damage in %	
	light	shade	light	shade	light	shade
Qu. petraea						
Apr. 18	17.64	21.14	0.1754	0.1539	—	—
May 4	110.04	169.96	0.6341	0.6273	11.55	7.71
10	153.61	157.19	0.8994	0.8882	27.11	16.84
24	157.18	222.64	1.2426	1.1941	18.07	9.72
June 13	162.79	160.61	1.7061	1.2781	38.41	19.09
27	160.39	174.90	1.9133	1.2932	19.56	12.85
July 27	164.08	178.49	2.1063	1.5380	22.90	23.03
Aug. 23	145.22	170.05	1.7319	1.2811	17.71	11.07
Sept. 26	141.15	168.74	1.9160	1.4947	21.55	21.47
Oct. 17	157.80	150.45	2.1161	1.0472	21.98	12.37
Qu. cerris						
May 4	17.42	17.42	0.1431	0.1431	1.95	1.95
10	51.43	64.68	0.3708	0.3263	5.58	1.93
24	89.52	92.03	0.6093	0.5293	3.76	5.60
June 13	94.33	104.50	0.9257	0.7131	6.34	9.58
27	85.37	89.43	0.9317	0.6279	8.56	14.60
July 27	81.25	104.09	1.0969	0.7552	8.21	5.80
Aug. 23	98.66	91.09	1.3656	0.7712	12.82	11.53
Sept. 26	116.03	118.91	1.7574	1.1184	8.62	12.86
Oct. 17	79.31	104.76	0.8417	0.8238	6.69	8.72

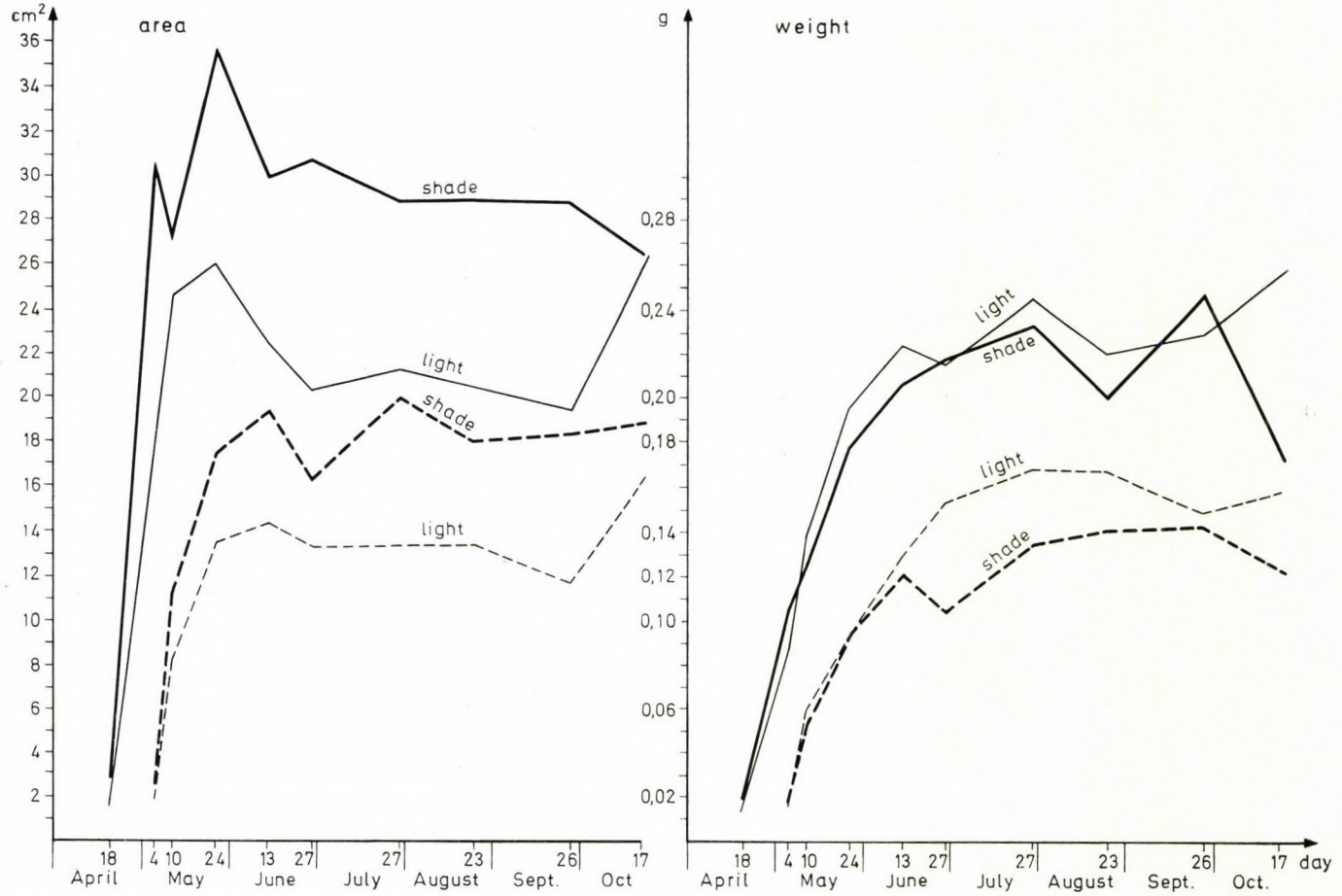

Fig. 2. Seasonal modification of reconstructed area and weight of light- and shade-adapted leaves of *Quercus petraea* (solid line) and *Quercus cerris* (dotted line)

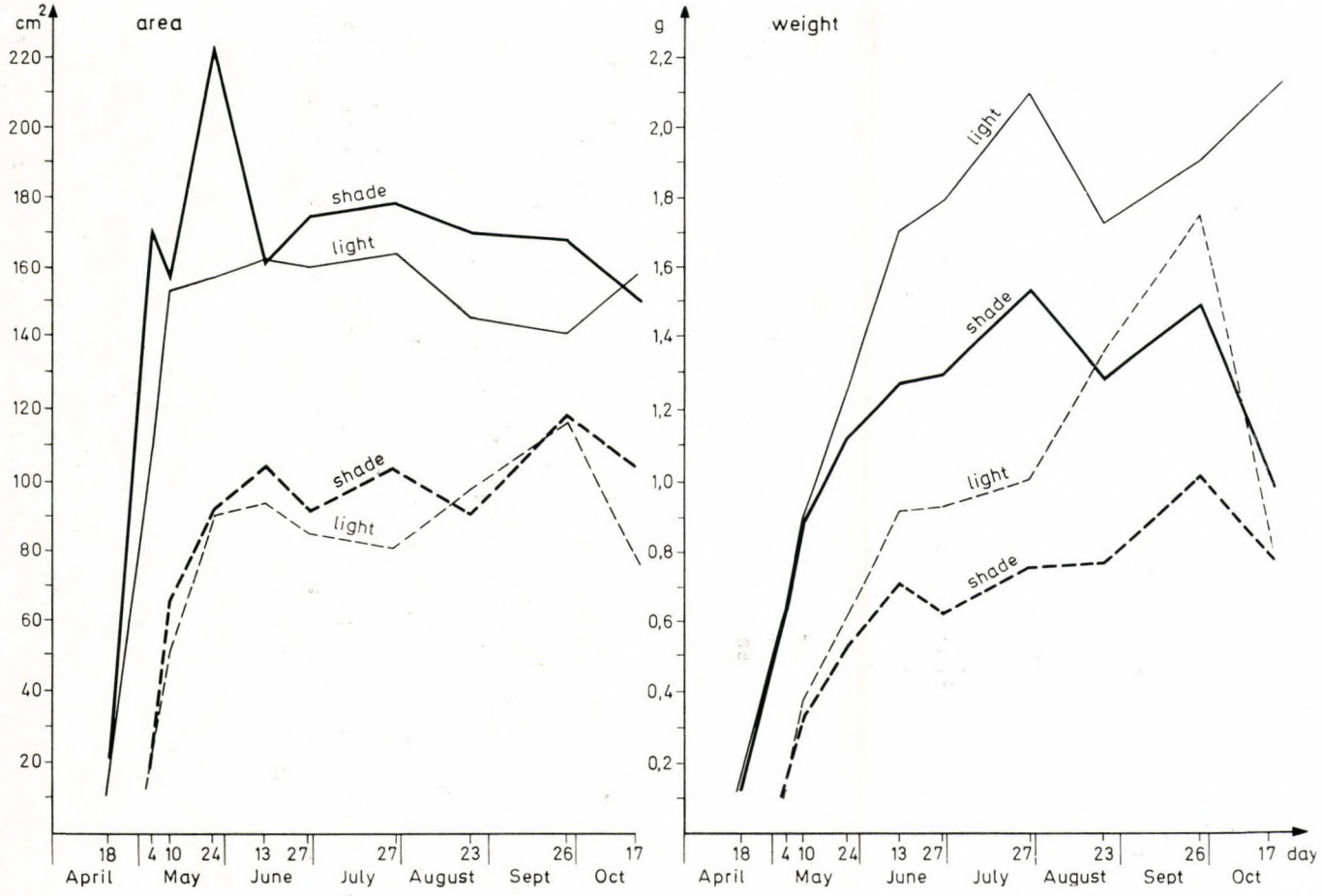

Fig. 3. Seasonal change of reconstructed area and weight of light- and shade-adapted shoots of *Quercus petraea* (solid line) and *Quercus cerris* (dotted line)

However, in the cited case one may also assume that not only radiation effects but the xerothermic character of the microenvironment also plays a role in the retarded development of leaf area.

Leaf growth of *Quercus petraea* is very rapid during the spring and by the end of May both the light- and shade-adapted leaves have almost reached full development. A later difference of size between the light- and shade-adapted leaves appears at the end of May when foliage is completely developed and its stratifications according to light intensity levels becomes more pronounced. Leaves which have reached their fully developed and maximum area by the end of May experience an abrupt decrease of average dimensions in June, and this state scarcely alters during the subsequent vegetation period. This regression is significant primarily in the case of shade-adapted leaves and could be observed only in the case of *Quercus petraea*. The reason obviously lies in the fact that the average area of the great number of fresh and young leaves, developing in May and June after the extensive caterpillar damage, is rather small.

From June till autumn the leaf area showed little variation in size; their areal growth had been essentially completed. Nevertheless, in the uppermost stratum a sudden increase of leaf area for both species could be noticed in October. To identify the principle underlying this phenomenon further research is necessary.

Leaf development in *Quercus cerris* started approximately two weeks later. Maximum areal values were reached only by the middle of June. In the case of shade-adapted leaves a regression in the areal growth process has set in at the end of June and the maximum was reached in July, a fact perhaps related to the second leafing following damages caused by caterpillars. The leaf area of *Qu. cerris* is considerably smaller than that of *Qu. petraea*, a characteristic of this species.

The shoot area has reached its maximum in the middle of May and June, respectively, for both tree species. Nearing the end of the vegetation period areal regression becames noticable. At summer's beginning, the areal loss of shade-adapted shoots associated with caterpillar damage was perhaps more extensive than in the case of leaves.

Changes in weight

Changes in dry weight of the leaves and shoots in the course of time showed an entirely different picture than areal modifications. During the spring season gain in weight was slighter, more gradual. Generally the maximum in both light levels was reached by the representatives of the two different species by the end of July and the beginning of August. Deferment of leaf development had considerably less influence on weight regardless of the species.

After maximum weight had been reached, no significant change occured. At the end of the vegetation period, in October, weight decrease has set in which can be explained by the translocational processes of the fall season. Decrease of weight was most significant in the case of the shade-adapted shoots, in contrast to even a slight growth of light-adapted leaves of *Quercus petraea* (where also an areal increase occurred).

The weight of the light-adapted leaves was always more considerable than that of the shade-adapted leaves, with the exception of the early spring period when the density and shading effect of the canopy is less prominent. The collected data reflect the pattern that despite their smaller area the accumulation of organic matter is more intense in the light-adapted leaves — although their area is smaller — than in the shade-adapted leaves (this can be especially expressed in the case of *Qu. cerris*). Thus photosynthetic activity decreases in the lower stratum of the crown (according to DYLIS—KARPOV—TZELLNIKER, 1966, it is occasionally merely one tenth of that occurring in the light level). There can be no doubt, however, that no complete and precise explanation can be given without regard to respiration and translocation "losses". The greater average weight of light-adapted leaves can be related also with the more advanced development of the assimilating tissues, of the palisade parenchyme layer, and thus of their thickness. One may also assume that excess weight is due to inclusions, mainly of the presence of Ca-oxalate crystals. This, however, is contradicted by the analysis of the mineral content of light-adapted leaves which indicates that more Ca is always detectable in shade-adapted leaves (B. PAPP, ined.).

Seasonal changes in shoot weight show a tendency similar to that of leaves. Based on the total number of leaves, the reconstructed total leaf and shoot area, respectively, and their dry weights per hectare are summarized below. (The number of leaves has been supplied by B. PAPP, for September 1973; the authors have calculated areal and weight data based on the mean values obtained in the light and shade levels also for September).

		Number/hectare	m^2/ha	kg/ha
Quercus petraea	leaf	27 897 000	67 427	6 673
	shoot	4 649 500	72 044	7 929
Quercus cerris	leaf	5 481 250	8 288	795
	shoot	783 000	9 198	1 126

Extent and effect of caterpillar feeding

Based on whole leaf area and the reconstructed area of caterpillar-eaten leaves on the shoots 30 shoots per light levels we computed the percentage of damage for each sampling period and for both tree species (see Table 2).

The data point to the fact that especially in the case of *Qu. petraea* damages caused by caterpillars were considerable (Fig. 4). Furthermore, caterpillar damage reached its climax twice during the vegetation period in the forest ecosystem; the first climax at the beginning of May, the second in the middle of June. Damage induced in the spring was due chiefly to *Tortrix viridana* and to a lesser extent to *Hybernia defoliaria*. Maximum damage in June was caused by the caterpillar of *Lymantria dispar* (VARGA, personal communication).

The maximum is always a function of weather conditions as well. The caterpillars of *Tortrix viridana* hatch at the beginning of April, but damage on

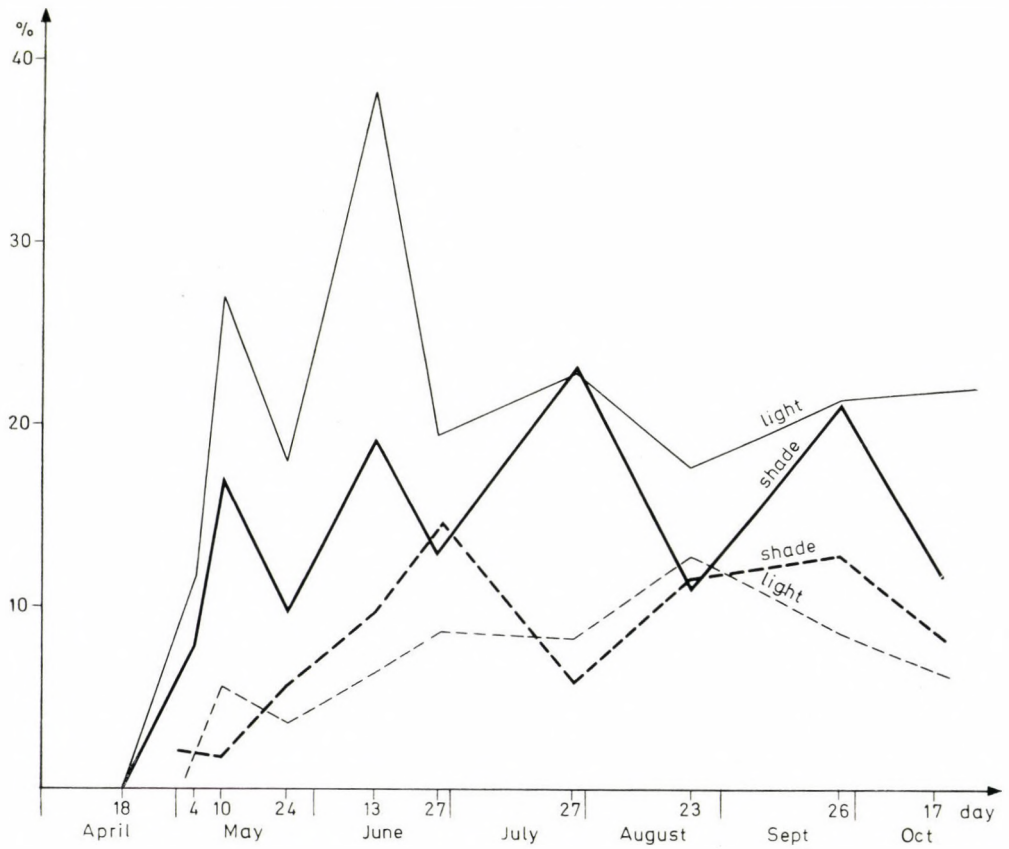

Fig. 4. Extent of caterpillar induced damage of the light- and shade-adapted leaves of *Quercus petraea* (solid line) and *Quercus cerris* (dotted line)

a large scale could be observed only at the beginning of May. This shift was due to the coolish but dry spring. Field surveys indicated that the light-adapted leaves and shoots suffered heavier damage than the shade-adapted leaves and shoots, respectively. Shade-adapted leaves and shoots exhibited a damage peak at the end of July, but the degree of damage, as compared with the first two maxima measured in the light level, was notably less. The most likely explanation is that young leaves developing during the second leafing period were more favoured by the caterpillars than the older, larger well-developed ones. Furthermore it may be connected also with the destruction wrought by the gradation of *Calymnia trapezina* around the end of of July and the beginning of August.

If the damages, expressed in percentage, are compared for both oak species, it can be stated that *Quercus cerris* suffered considerably less than *Qu. petraea*. The main reason is probably that *Qu. cerris* starts to unfold its foliage about 2 weeks later, and this brief phenological difference offers a significant protective advantage for the Turkey oak against *Tortrix*. Hatched by this time, the caterpillars of this species were feeding on the young leaves of *Qu. petraea* and migrated to trees of another species (e.g. to *Qu. cerris*) only in want of food.

As a last remark, attention must be called to the fact that the authors have practically no data at hand on the damaging affect, and the extent of the damage which larvae exert on buds. For it is evident that the first enormous damage is caused in the buds by the minute caterpillars emerging from the eggs. Accordingly, the real loss of potential assimilating area is considerably greater than measurements have indicated. Bearing in mind that numerous leaves were completely devoured by the caterpillars (in some cases even the midrib was left in mutilated condition), it is justified to maintain that the real loss for one hectare is at least 10% greater than actually measured.

Calculating the loss of assimilating area and weight, respectively, for one hectare the measurement data are as follows:

	%	m^2/hectare	kg/hectare
Qu. petraea	30.72	26 421	2 047
Qu. cerris	13.71	1 257	114

In cognizance of the reconstructed areal and weight data of the total leaf number, the above values were calculated of the basis of the respective damage percentages (the means of the light and shade level maxima !).

The given m^2/ha and kg/ha values and the percentage of material loss (the extent of damage expressed in percentage) were probably 10% higher owing to the reasons mentioned above (i.e., 41 and 24%, respectively).

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VERÄNDERTE KNOSPENENTWICKLUNG AN JOHANNISBEEREN (RIBES SP.) BEI BEFALL DURCH DIE JOHANNISBEERGALLMILBE (CECIDOPHYOPSIS RIBIS WESTW.)

Von

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AUS DER SEKTION BIOLOGIE DER UNIVERSITÄT ROSTOCK, DDR

(Eingegangen am 25. August 1974)

The buds of Ribes species for the next year appear already in spring. After the vegetative phase (development of tegments and leaf primordia), the shoot apex may be transformed into inflorescence. The development of buds infested with *Cecidophyopsis ribis* Westw. is disturbed, and leaves and inflorescences fail to form. The paper describes histogenetic deformations of proto- and subprotoderm and discusses the causes of these phenomena.

1. Die normale Ontogenese der Axillaren bei Ribes

1.1. Vegetative Phase

Bei den *Ribes*-Arten werden die Knospen für das kommende Jahr bereits im Frühjahr angelegt. Der Vegetationskegel dieser Axillaren ist relativ klein und nur von wenigen Tegmentprimordien umgeben. Nach Beendigung der ersten Entwicklungsphase ist die für viele Dikotylenscheitel charakteristische Schichtung der Meristemkomplexe gut erkennbar (vergl. Zusammenfassung bei KAUSSMANN 1963).

Protoderm (Pr) und Subprotoderm (sPr) wachsen mit eigenen Initialen, die sich im Scheitelabschnitt der Sprossspitze nur antiklinal teilen. Seitlich kann es im Subprotoderm zu periklinalen Teilungen kommen, wodurch die Blattbildung eingeleitet wird. Die antiklinale Teilungsrichtung führt zu einem ausgeprägten Oberflächenwachstum.

Unterhalb des Subprotoderms befinden sich im Spitzenbereich die unregelmässig angeordneten, ± vakuolisierten Zellen des Zentralmeristems (ZM). Sie teilen sich allseitig (Volumenwachstum) und führen basal laufend Derivate dem Flanken- und Rippenmeristem (FM, RM) zu. Die Zellen des Flankenmeristems sind relativ schmal und intensiv färbbar. Aus den Abkömmlingen dieses Meristems gehen die Prokambienstränge und die primäre Rinde hervor. Das Rippenmeristem, dessen Zellen vergrössert und vakuolisiert erscheinen, liefert die Lang- und Kurzketten des jungen Markes. In einiger

Entfernung vom Spitzenmeristem werden die Blattanlagen ausgegliedert. Der Blattbildungsprozess beginnt mit der Streckung einiger subprotodermaler Zellen. Anschliessend setzt eine verstärkte Teilungstätigkeit im Flankenmeristem und im Subprotoderm ein. Das Protoderm beteiligt sich nur durch antiklinale Teilungen an diesem Wachstum und überzieht als einfache, später die Epidermis liefernde Zellage die Blatthöcker (Bl) (vergl. auch KAUSSMANN 1941, 1963).

Gelegentlich ordnen sich die Zellen unterhalb des Subprotoderms in Lagen an, so dass der Vegetationskegel von mehr als zwei Zellagen umgeben erscheint. Das ist besonders dann der Fall, wenn der Apex kurz vor der Ausgliederung einer neuen Blattanlage stark an Breite zugenommen hat (Maximalfläche) oder auch bei Eintritt in die präflorale Phase. Diese durch antiklinale Teilungen entstandenen Lagen sind instabil.

Nachdem eine Anzahl Knospenschuppen gebildet wurden, entstehen zwei nebenblattlose Laubblätter, die eine plikative Knospenlage zeigen. Zuweilen kann die Laubblattbildung in den generativen Knospen bei *Ribes rubrum* (vorwiegend an weissfrüchtigen Sorten) übersprungen werden. Es erscheinen dann nach den Tegmentprimordien die Brakteen, in deren Achseln die Blüten entspringen.

An *Ribes nigrum* war diese Entwicklung nicht zu beobachten. In Ausnahmefällen kommt es bei schwarzfrüchtigen Sorten zu einer gewissen Frondosität, da Blütentragblätter Laubblattgrösse und -form erreichen können. Diese Erscheinung kann z. B. an Terminalknospen von Langtrieben auftreten (LENZ 1960).

1.2. Bildung der Infloreszenz

Der Übergang zur reproduktiven Phase, d. h. die Bildung des Blütenstandes, beginnt mit einer Aufwölbung bzw. Transformation der vegetativen Sprossspitze. Durch ein gefördertes Längenwachstum verjüngt sich der Apex, und es entsteht ein "Meristempflock", der als noch undifferenzierte Blüten- bzw. Infloreszenzanlage aufzufassen ist (BRAUN 1957; JENTSCH 1957; KAUSSMANN 1963; KLOPFER 1968; RAUH und REZNIK 1951 und 1953 u. a.).

Das Oberflächenwachstum des Protoderms und Subprotoderms wird beibehalten, der Plastochronformwechsel entfällt. Im zweiten Schritt der präfloralen Phase, die die florale Phase einleitet, tritt eine Erstarkung des Scheitels ein, die mit einem ausgeprägten primären Dickenwachstum verknüpft ist, das sich hauptsächlich im Markkörper abspielt. Diese Prozesse führen zum sog. Ringwallstadium. Der Übergang von der präfloralen in die florale Phase deutet sich durch die beginnende Differenzierung der Tragblattprimordien und der Blütenhöcker an. Da die Blütenstände der Johannisbeeren brakteose Trauben sind (vergl. KAUSSMANN 1969; TROLL 1969), ent-

stehen die Blütenprimordien in akropetaler Reihenfolge, wobei der florale Kegel unmittelbar nach der Ausgliederung eines Blütenhöckers relativ flach erscheint.

Die basalen Blütenstiele weisen kleine Vorblätter auf, die dem unterständigen Fruchtknoten stark genähert erscheinen, jedoch nicht auf gleicher Höhe stehen. Da sie verschiedenen Nodien angehören, wird der Blütenstiel in Hypo-, Meso- und Epipodium gegliedert. Die Ausbildung der Vorblätter wird in akropetalen Richtung gehemmt. Bei *Ribes rubrum* fehlen sie im Endabschnitt der Traube gänzlich.

In der Scheitelregion der Infloreszenz wird das Meristem zur Bildung der distalen Brakteen und Blütenanlagen weitgehend aufgebraucht. Das verbleibende Spitzenrudiment tritt daher nach aussen hin nicht in Erscheinung. Auch die dem Scheitel unmittelbar benachbarten Lateralblüten kommen voll zur Entfaltung. Blütenrudimente, wie sie oft im Scheitelbereich als Produkte einer progressiven Entwicklungshemmung häufig sind, fehlen bei den als Beerenobst kultivierten *Ribes*-Arten (Troll 1969).

Selbst bei stark reduzierten Infloreszenzen mit pseudoterminalen Blüten und einer sterilen Braktee haben wir es mit offenen Trauben zu tun.

Bemerkenswert klein sind die Blütenblätter, die vom Kelch überragt werden. Beide sind mit der becherförmigen Blütenachse verwachsen. Die Staubblätter behalten auch zur Zeit der Vollblüte ihre einwärtsgekrümmte Knospenlage bei und zeigen sich in der Blütenaufsicht daher von ihrer morphologischen Unterseite.

Die nicht septierte Ovarhöhle wird von zwei Fruchtblättern mit zwei partiellen Plazenten, die zahlreiche Samenanlagen tragen, gebildet. Auf dem unterständigen Fruchtknoten stehen zwei ± miteinander verwachsene Griffel. In die beerenartige Ausbildung des Perikarps wird auch die das Ovar umkleidende Achsenkupula einbezogen (Engler 1964). Die Postfloration beginnt mit einem starken Wachstum des Ovars. Der Kelch schliesst sich, bleibt aber im vertrockneten Zustand auch an der reifen Frucht erhalten.

Zusammenfassend kann gesagt werden, dass es sich bei der Gattung *Ribes* um Infloreszenz-Kurztriebe handelt, deren Internodien ± stark gestaucht sind. Die Knospen werden gewöhnlich aus zahlreichen Tegmenten, ein oder zwei Laubblättern und den schuppenförmigen Hochblättern, in deren Achseln die Blüten (ohne Gipfelblüte) stehen, gebildet. Nach der Fruchtreife fällt der Kurztrieb entweder ab, oder er wird in sympodialer Weise von einer Achselknospe des oberen Laubblattes weitergeführt (Rauh 1950).

2. Die veränderte Knospenentwicklung bei Ribes sp. infolge des Gallmilbenbefalls

In der Zeit von Ende April bis Anfang Juni verlassen die Johannisbeergallmilben die alten Gallknospen, um in die gebildeten Jungknospen einzudringen und sich im Bereich des Vegetationskegels anzusiedeln. Es sind durchschnittlich 4 bis 5 Tiere, die den Ausgang für den Aufbau einer Population von etwa 7000 bis 11 000 Gallmilben darstellen. Die Tiere ernähren sich offenbar vom Zellsaft der peripheren Meristemzellen des Apex sowie den Epidermiszellen der Tegmentprimordien. Dabei gelangen wahrscheinlich Stoffe mit Wuchsstoffcharakter in die angegriffenen Zellen (Lit. bei SCHÄLLER 1970).

2.1. Veränderungen am Protoderm

Die ersten Anzeichen einer Reaktion der Wirtspflanze auf den Parasitenbefall treten bereits Ende Mai im Bereich des Vegetationskegels in Form auffälliger Veränderungen des Protoderms auf.

Die Zellen hypertrophieren bzw. vergrössern sich. Der Turgor dieser Zellen scheint hoch zu sein, denn die äussere Zellwand wölbt sich stark konvex hervor (Abb. 1). Auffallend ist die intensive Färbbarkeit mit Hämatoxilin gegenüber einem ungestörten Protoderm. Diese "Riesenzellen" besitzen oft mehrere Zellkerne. Mitose und Wandbildungsprozess können zeit-

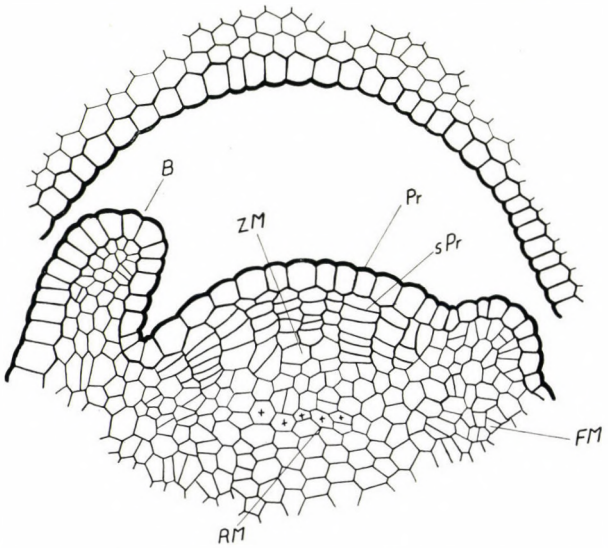


Abb. 1. Sprossspitze einer befallenen Knospe von *Ribes nigrum* (12. 6. 68). Das hypertrophierte Protoderm (Pr) ist deutlich erkennbar. Darunter befinden sich Kurzketten — entstanden durch periklinale Teilungen des Subprotoderms (sPr). Die Gruppe der Zentralmeristemzellen (ZM) erscheint zurückgedrängt. B = Blattanlage, FM = Flankenmeristem, RM = Rippenmeristem

lich von einander getrennt sein. Später gebildete Zellwände stehen häufig schräg, da die Polarität der Zellen gestört ist. In befallenen Knospen kann die Anzahl der Protodermzellen am vegetativen Kegel um 50 bis 80% im Vergleich zu normalen Kegeln zunehmen.

2.2. Veränderungen am Subprotoderm

Atypische Veränderungen im Subprotoderm treten nur an Vegetationskegeln auf, deren Protoderm bereits stark verbildet ist. Anfänglich werden kleinere Verwerfungen in der Architektonik des Subprotoderms und darunter liegender Zellgruppen sichtbar. Auffällige Anomalien im Subprotoderm stellen Kurzketten dar, die durch periklinale Teilungen in Zellen unmittelbar über dem Zentralmeristem entstehen (Abb. 1). Auch hier liegt eine deutliche Polaritätstörung vor, da diese Gruppe der Subprotodermzellen an der Sprossspitze normalerweise nur antiklinal aufgliedert und somit zu einem Oberflächenwachstum beiträgt. Die Polaritätsänderung führt nun zu einem Volumenwachstum der subprotodermalen Elemente. Die in antiklinalen Reihen angeordneten Segmente drängen die Gruppe der Zentralmeristemzellen nach innen. In den befallenen Knospen ändert sich der gesamte Entwicklungsrhythmus. Durch ein verstärktes primäres Dickenwachstum in dem jungen Markgewebe (medulläre Form nach TROLL und RAUH 1950) werden die Ansätze der Tegment- bzw. Laubblattanlagen annähernd in eine Ebene gehoben (Abb. 3), so dass eine Scheitelebene entsteht. Ferner wird der normale Ablauf der präfloralen bzw. floralen Phase unterdrückt oder erheblich gestört. Da die Blütenanlagen in den sich zu Gallen umbildenden Knospen häufig verlauben, kann die Anzahl der Blattanlagen vermehrt werden. In den befallenen Knospen entwickeln sich keine Laubblätter, sondern schuppenartige Gebilde, die ein verstärktes Wachstum erkennen lassen, das zu einer starken Fältelung und blasigen Aufwölbung der Oberfläche führt. Hand in Hand mit der gestörten inneren Knospenentwicklung geht eine Veränderung der äusseren Form einher. Die Knospe nimmt eine typisch kugelige bis breitrunde Gestalt an (Gall- oder Rundknospe). Auffällig sind ausserdem die Farbveränderungen der Blattprimordien in befallenen Axillaren. Schon Anfang Juni erkennt man die von Gallmilben besiedelten Knospen im geöffneten Zustand an der weisslichen bzw. chlorotischen Färbung der inneren Schuppen. An Stelle des normalen Grüns gesunder Blattanlagen treten im Verlauf der Cecidiogenese blassgelblichgrüne bis bräunliche Farbtöne auf.

Aus der einschlägigen Literatur ist bekannt, dass in Gallen- und Tumorgeweben die Chlorophyllbildung gestört oder unterbunden sein kann (KÜSTER 1956). Zu Beginn der Gallenentwicklung (Mai bis Juli) wird die Innenfläche der jüngsten Blattprimordien zu unregelmässig meristematischen Epidermiswucherungen angeregt. Ab August erstreckt sich dieses abnormale Wachstum

auch auf die Aussenseiten der Blattanlagen (Meristemoide — vergl. KAUSSMANN 1963). Die enorme Teilungsrate der jungen Epidermiszellen an den Innen- und Aussenseiten der Knospenschuppen führt zu erheblichen Gewebespannungen im Mesophyll, so dass in der Regel unterhalb der subepidermalen Lage auf weiten Strecken rhexigene Hohlräume gebildet werden, die mit Luft erfüllt sind (Abb. 2 und Abb. 3). Besonders an Gallen schwarzer Johannisbeeren (Sorte "Pobjeda") sind diese Gewebeschäden zu beobachten (Abb. 3). Die proleptische Entwicklung von Seitenknospen in den Gallen lässt darauf schliessen, dass die phytohormonale Hemmwirkung des durch den Gallmilbenbefall degenerierten Vegetationskegels auf benachbarte Meristeme bzw. Meristemoide gering ist. Seitenknospenanlagen werden auch in normalen Knospen schon im Laufe des Sommers als kleine Meristemhöcker in einiger Entfernung vom Scheitel sichtbar. Das Hemmungsfeld des Scheitelmeristems als Ort höherer Embryonalität ist jedoch noch so stark, dass deren Weiterentwicklung zu Seitensprossen unterdrückt werden kann. BÜNNING (1953) spricht von Sperreffekten, hervorgerufen durch Auxinproduktion der Spitzenmeristeme. Entfällt die hormonale Hemmung der embryonalen Bildungszone der Sprossspitze, so werden ruhende Meristeme bzw. Meristemoide in dessen Umgebung aktiviert (vergl. auch KAUSSMANN 1955). Die Seitenknospen in den Gallen bilden bereits im Sommer neben den Tegmentanlagen ein bis zwei wohlgegliederte Laubblätter, eine Erscheinung, die in befallsfreien Knospen zur gleichen Zeit nicht zu beobachten ist. Das starke vegetative Wachstum der Gallen scheint einen Einfluss auf den qualitativen Entwicklungsverlauf dieser Axillaren innerhalb der Gallen zu haben, da in diesen nur sehr selten Blütenanlagen gebildet werden.

Auffallend ist, dass die Epidermiszellen innerhalb des Lebensraumes der Gallmilben mehr oder weniger stark hypertrophieren und teilweise auch vielkernig werden. Durch fortgesetzte Teilung entstehen Protuberanzen (Abb. 4. u. 5, Abb. 4a, b, c). Die Hemmwirkung der einzelnen Protuberanzenmeristemoide verhindert offenbar die Bildung einer einheitlich mehrschichtigen Epidermis. Die Protuberanzen können wie aus Abb. 5. ersichtlich ist, auch keulenförmige Gestalt annehmen. Diese Gebilde lassen häufig ein längeres Spitzenwachstum erkennen, das sich in dem unter der subepidermalen Lage befindlichen Gewebeteil abspielt. Infolge der Protuberanzenentwicklung wird die normale "Musterbildung" der Blattorgane gestört, so dass die Bildung von Haaren und Drüsenschuppen in befallenen Knospen unterbleibt. Durch Injektion von Presssaft kältegetöteter Johannisbeergallmilben in junge Axillaren von *Ribes rubrum* und *Ribes nigrum* konnten besonders an Schwarzen Johannisbeeren ähnliche histologische Veränderungen, d. h. eine Protuberanzenbildung, erzeugt werden. An den vergleichsweise mit Aqua dest. gespritzten Knospen bildeten sich keine Wucherungen, sondern es entstanden nur kleine, auf die mechanische Verletzung zurückzuführende Missbildungen (einseitige Krüm-

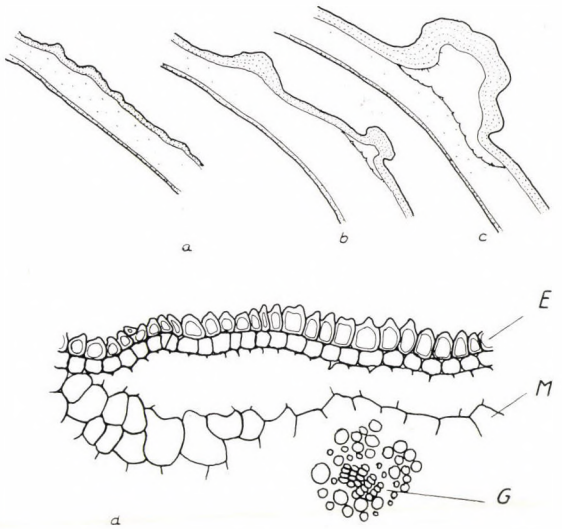


Abb. 2. Teile von Knospenschuppen (Schnitt) aus dem Zentrum einer befallenen Knospe von *Ribes nigrum* (18. 9. 68) mit fortgeschrittenen Epidermiswucherungen auf der Tegmentinnenseite (a—d). Als Folge der unnormal hohen Teilungsrate der Epidermiszellen treten rhexigene Hohlräume im Mesophyll auf. E = Epidermis, M = Mesophyll, G = Leitbündel

Abb. 3. Längsschnitt einer Gallknospe der Sorte »Pobjeda« (*Ribes nigrum*) kurz vor der Migration der Gallmilben im April. (Die Sprossspitze ist völlig degeneriert.) Es wurde keine Infloreszenzanlage gebildet. Die Schuppenblätter sind auffallend stark gefaltet und mit Epidermiswucherungen übersät. Die rhexigen gebildeten Hohlräume im Mesophyll sind gut erkennbar

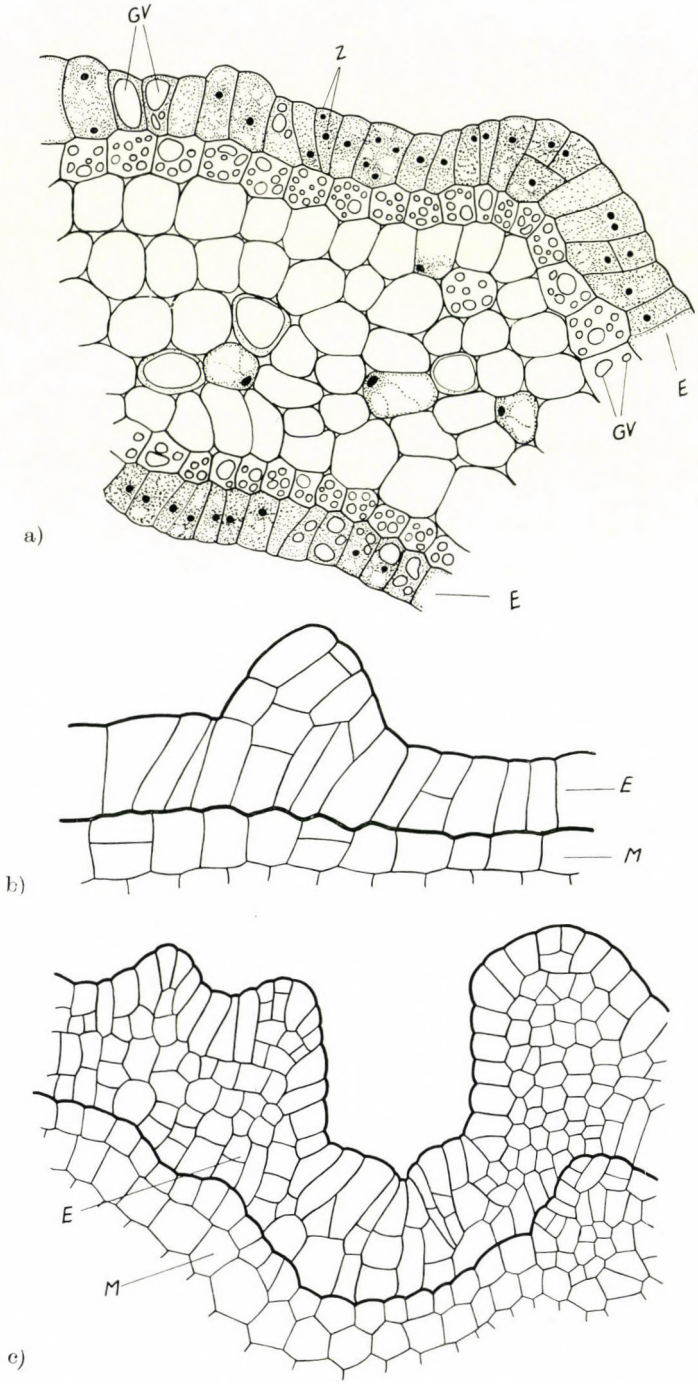


Abb. 4a. Querschnitt eines Tegments. Die Epidermiszellen (E) sind hypertrophiert, teilweise stark vergrössert und mehrkernig. Lokale Querteilungen in der Epidermis leiten die Protuberanzbildung ein. E = Epidermis; GV = Gerbstoffvakuolen; Z = Zellkern. *4b, c.* Fortschreitende Entwicklung der Epidermiswucherungen unter Einbeziehung subepidermaler Zellgruppen. E = Epidermis; M = Mesophyll

mungen). Da die eingewanderten Gallmilben und ihre Nachkommenschaft fast ein Jahr in der betreffenden Knospe leben, besteht ein permanenter chemischer Reiz auf das Gewebe, insbesondere auf die jungen Epidermen, der sich mit dem Anwachsen der Population ständig verstärkt. Die Wirtspflanze reagiert — die Winterruhe ausgenommen — mit einer ständigen Neubildung embryonaler Zellen. Dieser Prozess dauert bis zum Vertrocknen der Gallen im Mai/Juni des folgenden Jahres an. Offenbar besteht eine Beziehung zwischen dem durch die Gallmilben angeregten embryonalen Wachstum in der Knospe und der Ernährungssituation der Tiere. Ende Juni besitzen etwa 10 bis 15% der befallenen Jungknospen einen floralen bzw. präfloralen Apex. Die Anzahl befallener Knospen mit Infloreszenzanlagen geht mit fortschreitendem Vergallungsprozess infolge Degenerationserscheinungen sehr stark zurück, so dass im nächsten Frühjahr kaum Gallen mit funktionsfähigen Blütenanlagen zu finden sind. Infolge der stofflichen Beeinflussung durch die Gallmilben tritt eine Umstimmung floraler Anlagen in vegetativer Richtung ein. An bereits

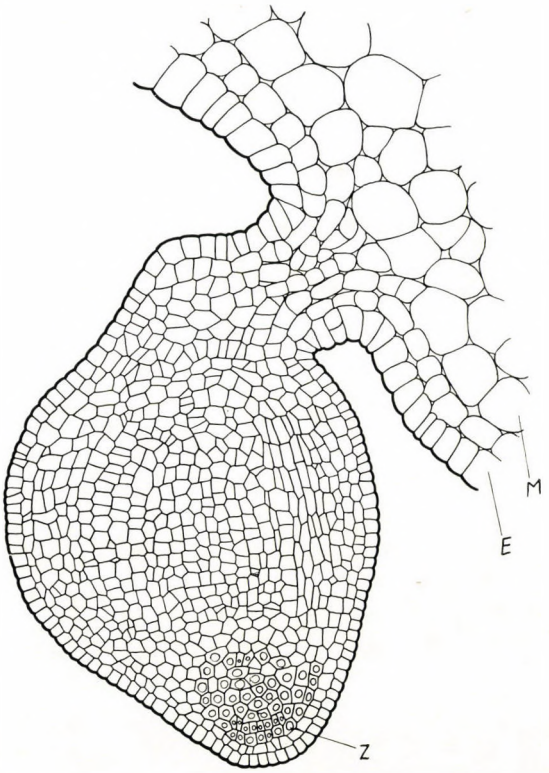
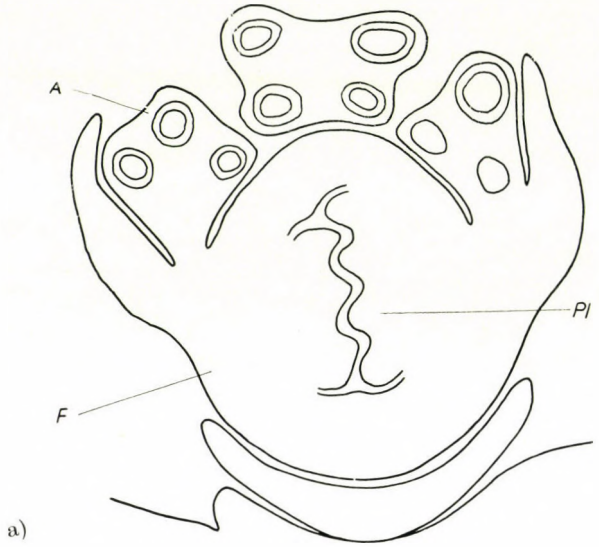
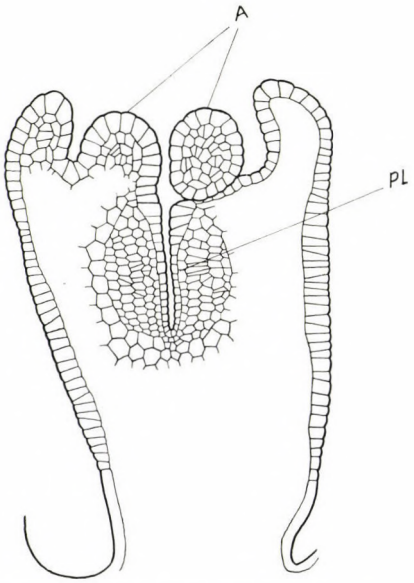


Abb. 5. Vielzellige keulenförmige Protuberanz. Die Zellen erscheinen relativ klein und geordnet. Es ist ein deutliches Spitzenwachstum zu erkennen. In die Zellgruppe mit verstärktem Wachstum wurden die Zellkerne eingezeichnet. E = Epidermis; M = Mesophyll; Z = Zellkerne

angelegten Infloreszenzen wird die Verlaubung gefördert (Abb. 6a, b, 7). Das mit der Entstehung der Blütenanlagen im wesentlichen abgeschlossene embryonale Wachstum einer Knospe wird wieder stark angeregt. Entscheidend



a)



b)

Abb. 6a. Schrägschnitt schematisch durch eine Blütenanlage aus einer unbefallenen Knospe von *Ribes rubrum* (18. 9. 68). Der Fruchtknoten mit den Samenanlagen und die Antheren sind deutlich erkennbar. F = Fruchtknoten; Pl = Plazenten; A = Antheren. *6b.* Schnitt (schematisch) durch eine degenerierende Blütenanlage aus einer befallenen Knospe von *Ribes rubrum* (18. 9. 68). Auffallend sind die stark hypertrophierten Epidermiszellen sowie die Streckung der gesamten Blüte. A = Antheren, Pl = Plazenten

für Ausmass und Schnelligkeit des krankhaft gesteigerten vegetativen Wachstums dürften die Anzahl der eingewanderten Gallmilben je Knospe als Ausgangssituation für die folgende Nachkommenschaftsentwicklung sowie die erreichte Entwicklungsphase des Vegetationskegels zur Zeit der Besiedlung sein. Die Anzahl der Junggallen mit generativen Organen ist deshalb so gering, weil die Mehrzahl der Jungknospen während der Migration der Gallmilben noch in der vegetativen Phase ihrer Entwicklung stehen. Die Frage der Cecidienbildung wird erst endgültig zu lösen sein, wenn wir die normalen systematischen Veränderungen in den Zellen, die spezifischen Differenzierungsprozesse in Verbindung mit der genetischen Information verstehen.

Einstweilen können die Gallen nur als Resultate einer durch exogene Faktoren (Einfluss der Parasiten) fehlgeleitete Entwicklung an bestimmten Teilen der betreffenden Pflanze beschrieben und gedeutet werden. Der Grad der Schädigung für die Pflanze ist um so grösser, je undifferenzierter und zahlreicher die von den Gallentieren angegriffenen Pflanzenteile sind.

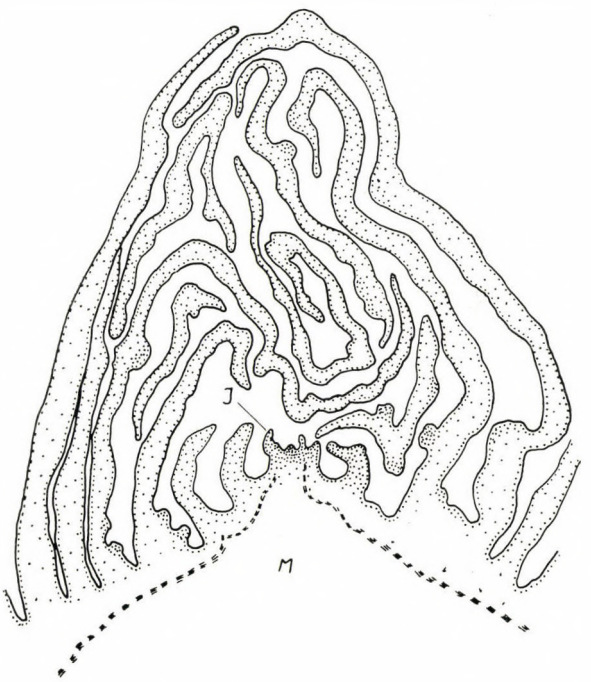


Abb. 7. Schnitt (schematisch durch eine Gallknospe von *Ribes rubrum* (Ende September). Die inneren Tegmente sind stark gefaltet. Alle Teile der Infloreszenz wachsen zu Schuppenblättern aus. Im jungen Mark hat ein verstärktes primäres Dickenwachstum begonnen, wodurch sich die Knospenbasis beträchtlich verbreitert. I = Infloreszenzrudiment, M = Bereich des verstärkten primären Dickenwachstums

Zusammenfassung

Bei den *Ribes*-Arten werden die Knospen für das kommende Jahr bereits im Frühjahr angelegt. Nach einer vegetativen Phase (Bildung von Tegment- und Laubblattprimordien) kann der Scheitel zur Infloreszenz transformiert werden. In Knospen, die von der Johannisbeergallmilbe *(Cecidophyopsis ribis*, Westw.) befallen sind, wird diese Entwicklung stark gestört, so dass es nicht zur Ausbildung von Laubblättern und eines funktionsfähigen Blütenstandes kommt. Die histologischen Missbildungen des Proto- und Subprotoderms werden beschrieben, ihre möglichen Ursachen diskutiert.

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THE APPLICATION OF SCANNING ELECTRON MICROSCOPICAL METHOD IN SOME PLANT MICROFOSSILS

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Scanning electron microscopical examinations were carried out with an SM-50A Jeol-type microscope in the species *Pleurozonaria concinna*, *Ovodites ligneolus* and two cf. *Oculopollis*. It was established that the pictures of high magnification (×15,000) provide essentially new data as far as surface sculpture is concerned. The submicroscopic sculpture of the examined two oculate *Normapolles* from the Upper Cretaceous is identical in both species, consequently this structure is probably an ecological and not species-specific characteristic. Taking into consideration the study by SRIVASTAVA (1972), it can be inferred on the basis of fine surface elements that the examined oculate *Normapolles* species. We obtained data also on the details of embedding which was taking place during fossilisation in the examined species.

Introduction

After the pioneering examinations by KAISER (1968), REYRE (1968), RIEGEL (1968) and TAYLOR (1968), several studies were published on scanning electron microscopical investigations into fossil spores and pollen grains. This method is already wide-spread in examining spores, pollen grains and plankton organisms. LEFFINGWELL, LARSON and VALENCIA (1970) obtained their results on *Wodehouseia spinata* Stanley 1961 by the complex method i.e. a combined application of the optical, transmission- and scanning electron microscopical instruments.

Owing to the possibilities offered by the electron microscopical method, the diagnoses of several taxa, which had been described by using an optical microscope have been supplemented.

The problem is that in paleopalynology the types of the various new taxa are represented by a single specimen and either a TEM or an SEM investigation into the typical sample is practically inextricable.

The purpose of this paper is to critically evaluate the results obtained by the scanning electron microscope which is at our disposal today. The resolution of the microscope is of 70—100 Å, which in comparison with that of the transmission electron microscope is considerably weaker. The problems related to the resolution capacities of the two kinds of instrument are well-known to specialists working with electron microscopes. The fact is that by the trans-

mission electron microscope partial data on such surface elements may be available that go undetected in the scanning instrument.

Material and method

Principles in selecting objects for investigation:

(1) Wherever it was possible, such forms were investigated that had already possessed some transmission data. This, of course, did not exclude the examination of organisms which had no pertaining data.

(2) On the basis of what has been said above, two plankton organisms (*Pleurozonaria concinna* (COOKSON and MANUM 1960) Mädler 1968, *Ovoidites ligneolus* (R. Pot. 1931) W. Kr. 1959, and two oculate *Normapolles* species (cf. *Oculopollis* fsp. 1,2) have been selected for examination. *Pleurozonaria concinna* was examined from the Jurassic material of Úrkút (cf. KEDVES and SIMONCSICS, 1964), *Ovoidites ligneolus* from the lower Eocene deposits of Mutigny and the oculate form-species from the Senonian deposite of Herend. Thus, microscopic fossils of different types, and of two different species of one pollen form-genus were examined.

The LEFFINGWELL and HODGKIN-type (1971) techniques (polyvinylchloride) were used for preparing the polyvinylchloride material, which had been covered with gold. The photograph were taken in the Electron Microscopical Laboratory in the Zoological Department of the Eötvös Loránd University (ELTE). We express our sincere gratitude also in this way to Dr. János KOVÁCS, lecturer, head of department, for his kind assistance and extensive support in our work.

Results

In the low-magnification picture of *Pleurozonaria concinna* (1 in Plate I), the surface characteristics, which had become known also by the optico-microscopical method, can be recognized. The distribution of the prominences which is characteristic of the genus is even. In the high-magnification pictures, the finer morphology of the prominences and also the endings of the tubules at the apex are recognizable. Entirely new observation is that on the wall-parts between the prominences there are small granular formations which stick out here and there. Thus, only the high-magnification pictures provided qualitatively new results.

Concerning the microscopical organisms belonging in the genus *Ovoidites* (R. Pot. 1951) W. Kr. 1959, there ample literary data are available (POTONIÉ, 1931; POTONIÉ and VENITZ, 1934; POTONIÉ, 1951; THOMSON and PFLUG, 1953;

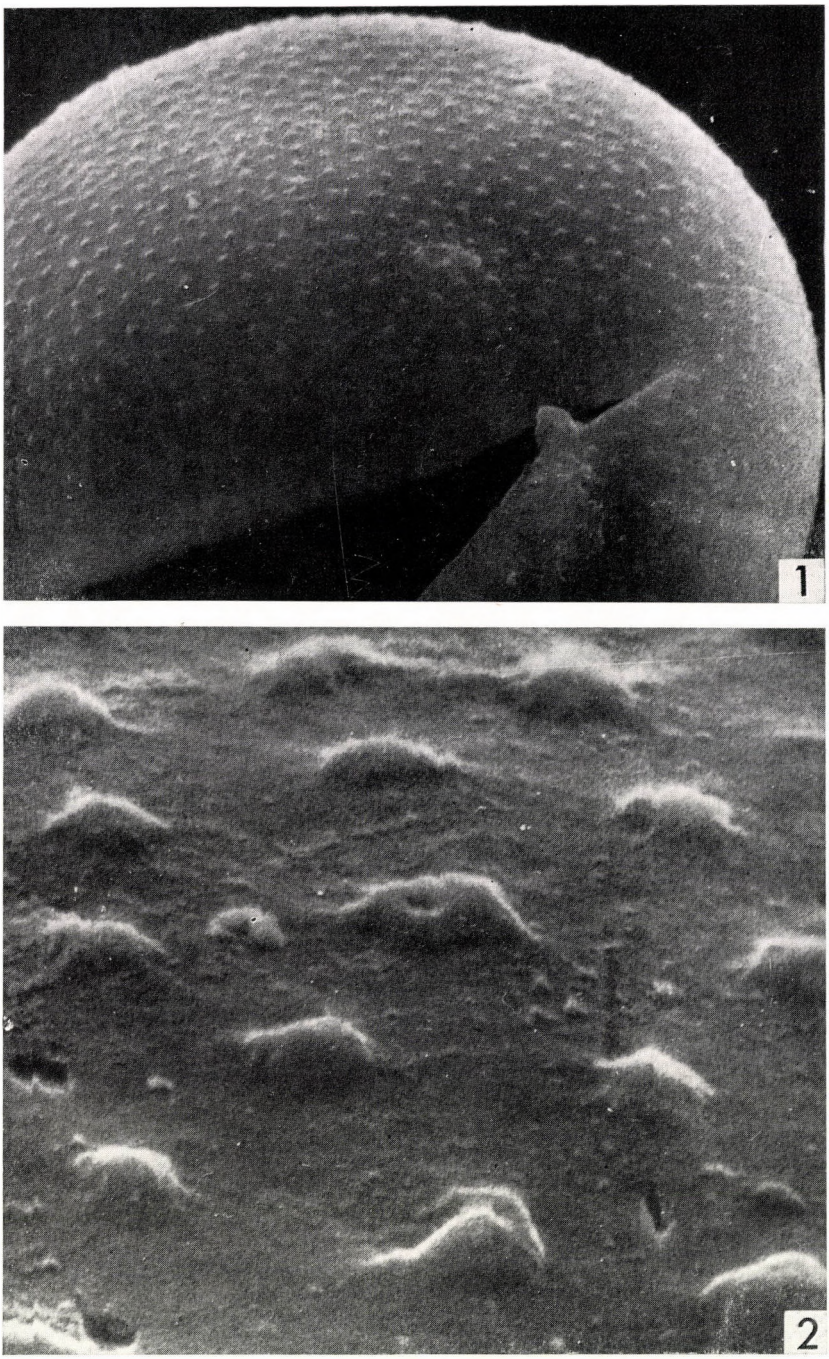

Plate I. — *1. Pleurozonaria concinna* (Cookson and Manum 1960), Mädler, 1968. Detail of the microfossil. ×1500; *2. Pleurozonaria concinna* (Cookson and Manum 1960), Mädler, 1968. Detail of the surface of the microfossil. ×15,000

KLAUS, 1950; OBRITZHAUSER-TOIFL, 1954; THIERGART, 1937; AGRANOVSKAIA, BOTSCHARNIKOVA and MARTYNOVA in POKROVSKAIA and STELMAK, 1960).

The pictures taken by the scanning electron microscope at low magnification (1 in Plate II) furnish information concerning the macrosculpture which is also observable by the optical microscope. The ornamentation varies from rugulate to corrugate, the protruding elements often show a reticulate pattern. The high-magnification pictures indicate that the ornamentation is more complex than had been described on the basis of earlier results. We consider the surface sculpture as complex corrugate when it consists of smaller and larger elements (2 and 3 in Plate II). The surface of these ornamentation elements is not entirely smooth but there are tiny granules, or small spiniform prominences on it, which, because of their small size, cannot be seen under the optical microscope. Again the scanning microscopical pictures yielded new results as far as ornamentation was concerned only when high-magnification was used.

The low-magnification SEM picture of cf. *Oculopollis* fsp_1 (1 in Plate III) furnish data on the spatial location and on the morphology of germinal openings of the oculus.

Contrary to the optical and the transmission electron-microscopical examinations, the high-magnification SEM pictures led to qualitatively new results concerning the examined cf. *Oculopollis* species. Namely, by the TEM pictures which had been taken earlier, spines concerning surface ornamentation could be demonstrated only (HEGEDŰS, KEDVES and PÁRDUTZ, 1971), while the scanning pictures furnished additional information i.e. on the finer structure of the surface. We established that the submicroscopical surface ornamentation is of two kinds. On the one hand, it consists of very small granules which cover also the larger prominences. Collectively, in superior view, they do not give the picture of the typical spines (2—4 in Plate III). These larger formations are also granules, they however often anastomose and form a submicroscopic, rugulate ornamentation. The formations evenly cover the whole surface of the pollen grain, there is no deviation even in the vicinity of the colpuses.

The scanning electron-microscopical pictures concerning these pollen grains furnished data also on the embedding rook, and the process of preparation. Since during preparation the surface of the examined samples was not entirely eleaned, consequently, fragments of the embedding rook occasionally adhered to the surface. This is on the basis of the results obtained a "film-like" layer, which has become adsorbed to the finally sculptured surface, strongly adhering to the surface, and it separated from the rest of the embedding rock. Assumably, it was only a very thin layer that adsorbed here, and in this way during embedding to the surface of the pollen grain, while the rest of the embedding rock has not become attached so closely to the pollen grain. The other parts of the embedding rock are easily detached during preparation

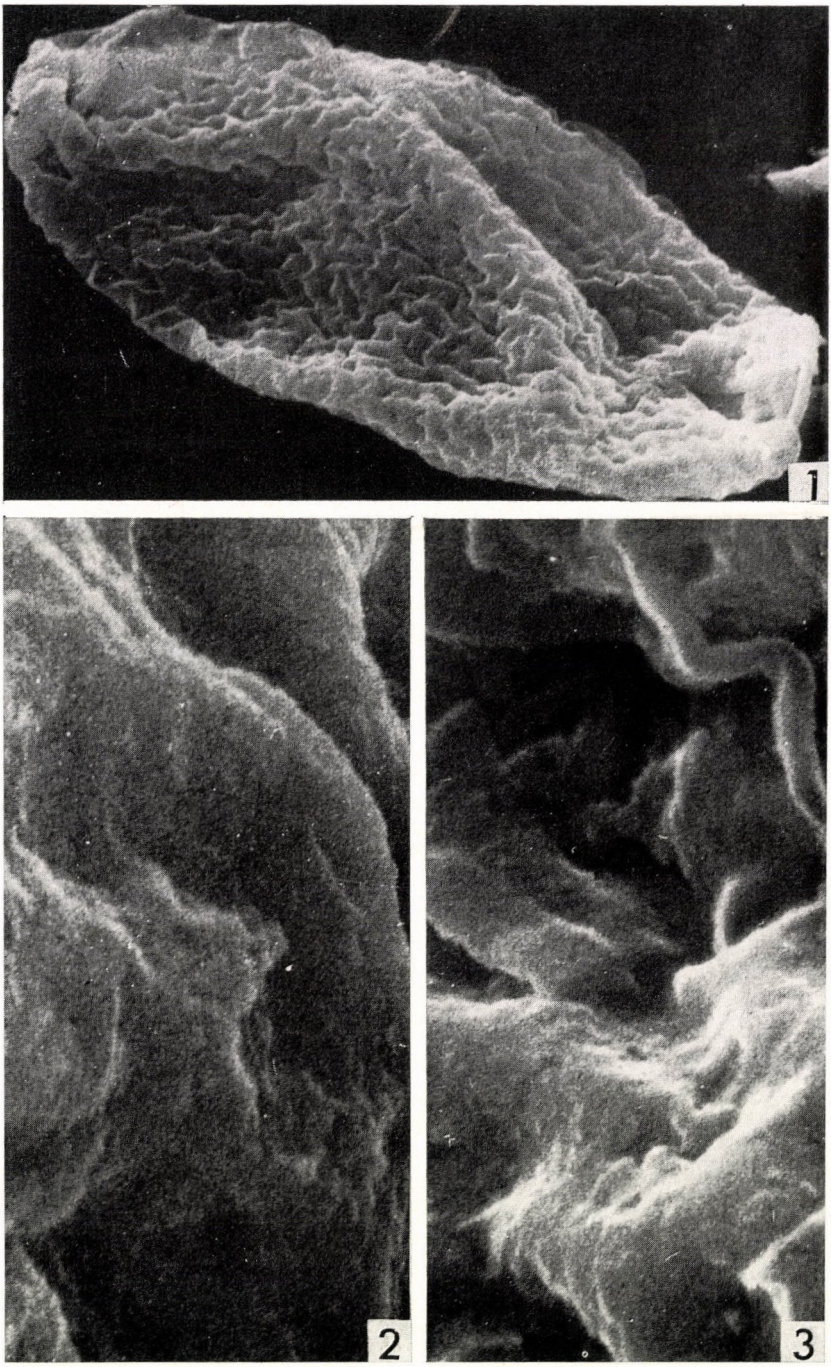

Plate II. — *1. Ovoidites ligneolus* (R. Pot. 1931) W. Kr. 1959. Surveying picture on the microfossil. ×1500; *2.* and *3. Ovoidites ligneolus* (R. Pot. 1931) W. Kr. 1959. Detail of the surface sculpture. ×15,000

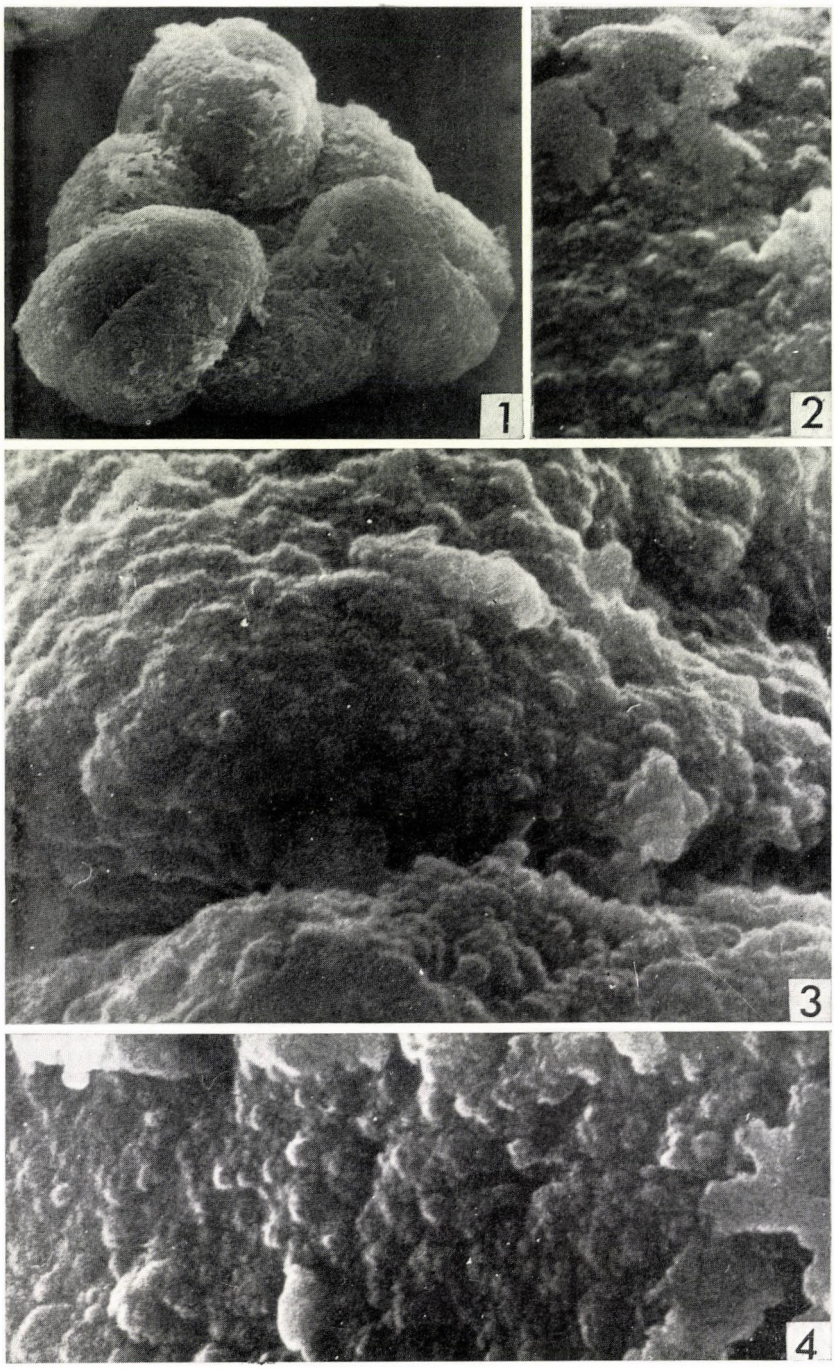

Plate III. — *1.* Cf. *Oculopollis* fsp. 1. Surveying picture of the pollen grain. ×1500; *2.* Cf. *Oculopollis* fsp. 2; Detail of the extragerminal surface sculpture, ×15,000; *3.* Cf. *Oculopollis* fsp. 2. Detail of the surface ornamentation of the colpus and the oculus, ×15,000; *4.* Cf. *Oculopollis* fsp. 2. Details sculpture of the extragerminal surface, ×15,000

but the complete removal of the fine film layer needs a stronger intervention. It should be mentioned here that the examined samples came from coaly-clayey layers. Although the scanning pictures do not provide detailed information on the nature of the film-like layer, the smooth surface of the covering part permits us to infer that this layer consists of probably colloid dimensional parts with extremely fine granules.

Discussion of the results

There occured little granules, not observable with the optical microscope, on the surface of *Pleurozonaria concinna* and of *Ovoidites ligneolus*. These features are probably of ecological importance, since they occured on two plankton organisms of rather different origin. The low-magnification picture of *Pleurozonaria* has not essentially furnished new data contrary to the results obtained with the optical microscope. In the case of *Ovoidites ligneolus*, primarily it was the high-magnification pictures that resulted in entirely data i.e. the reticulate sculpture which can be demonstrated by low magnifications, is no longer so expressed under high magnifications, the ornamentation of the surface is far more complex than it was indicated by the optico-microscopical data.

The submicroscopic surface ornamentation of the cf. *Oculopollis* species belongs in the "sculpture double" group described by REYRE (1968). Within this, it is similar a "mamelons et glomérules", although because of the larger anastomosing granules it cannot accurately be identified with that. It should by all means be emphasized that the fine sculpture elements, originally determined by REYRE (1968) for *Gymnospermatophyta* pollen grains, can be related to other plant microscopical fossils as well, at least to angiosperm pollen grains. On the other hand we should refer to the submicroscopical surface ornamentation of the two species that were found to be identical. There may be two reasons for this. (1) These characteristics are of mere ecological importance, i.e. they are related to pollination only. (2) The submicroscopical surface formations are of no specific value here. We can mention here the scanning electron-microscopical data of SRIVASTAVA (1972) *Extratriporopollenites nonperfectus* Pflug in: THOMSON and PLUG (*Trudopollis nonperfectus* Pf.), where spheroidal elements of relatively large size are scattered on the surface of the pollen grain. Thus, it may occur to someone that the fine sculpture of the surface may have differentiating values in the *Normapolles* pollen grains. To make a final decision further examinations are needed.

Summary

Our investigations indicate that in the scanning electron-microscopical examination of plant microscopic fossils two types of investigation should be distinguished, viz. low-magnification and high-magnification investigations carried out with electronmicroscopes of relatively high resolution. Low-magnification pictures which essentially supplement the optical microscopical investigations, are important from two viewpoints: (1) They furnish accurate data on the spatial arrangement of the morphological characteristics of microfossils that are observable also under the optical microscope. (2) They may also result in qualitatively new data in certain cases related to the apatial and to the surface distribution of ornamentation elements observable also by the optical microscope in microfossils.

Pictures of high-magnification furnish information on details of surface ornamentation not observable under the optical microscope, which are important taxonomically and probably from ecological viewpoints, too.

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CRYOBIOLOGICAL RESEARCHES IN THE HIGH TATRA I*

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The following microorganisms of cryoseston discolorations are known from the High Tatra: *Chlamydomonas nivalis* and *Ch. sanguinea* red snow, *Ch. flavovirens* and *Chlamydomas rostafinskii* yellow snow, *Chromulina ettlii* yellowish-brown snow, *Koliella tatrae* and *Carteria gyoerffyi* green snow. The snow vegetation of the High Tatra belongs to the third, higher cryovegetation type.

The cryobiological researches have recently taken a greater impetus in the Tatra Mountains. The snow pH measurements were made by KOL (see Tables 1 and 2); cryo-ecological, cryo-biological and physiological examinations as well as quantitative and photosynthetical measurements were carried out by HINDÁK, JAVORNICKY and KOMAREK (1973). HINDÁK and JAVORNICKY cultivate cryo-algae in laboratory also in pure cultures.

Coloured snow was a known phenomenon of nature to alpinists and arctic exploreres for some centuries. Cryobiological research progressed only slowly because researchers had to overcome numerous impeding difficulties.

For one thing, biotopes are difficult to access, examinations in situ are hindered by numerous factors, and finally, keeping the collected sample material alive also incurs much difficulty.

Three periods can be distinguished concerning cryobiological researches: (1) observation of the coloured snows; (2) identification of nivicolous microorganisms and their morphological, taxonomical, cytological research; (3) limnological, biological, quantitative researches, and the successful establishing of pure cultures of nivicolous microorganisms.

The first period of cryobiological research in the High Tatra began several centuries ago. The coloured snow of the High Tatra was for the first time mentioned by JAKAB BUCHHOLTZ who in 1751 saw red snow in the Mengusfalva Valley (Dol. Menguszowieckim) at about 2000 m altitude. This is also the first mention in literature of the coloured snow of the Tatra Mountain (BUCHHOLTZ, 1783; 1803; GYŐRFFY, 1927, 10—11; PARYSKI, 1951, 222—223). In 1872, A. J. CZIRBESZ saw red snow in the Poduplasky Valley (Svistovky Dol. Cefrorner See, Zmarzly Staw pod Polskim Grazebieniem) at 2047 m a. s. l., in 1872 (April 8th) CZIRBESZ observed green snow in the Handel Valley, above the Green Lake (Zielony Staw Wazecki) at 2026 m (CZIRBESZ, 1872; 1901). In 1876 (November 8th), T. CHALUBINSKI saw red snow in the Trümmer (Omladék Valley) the side valley of the Mengusfalva Valley, Puszta dolina, below the Western Iron Gate Pass (Dol. Zlomisk poviziej Zmarzlego Stawu) at 2100—2200 m (CHALUBINSKI, 1879; 1879a; 1901). In 1880, J. ROSTAFINSKI saw red snow in the Trüm-

* This paper is dedicated with gratitude to the memory of ISTVÁN GYŐRFFY bryologist, enthusiastic researcher to the High Tatra, and late Professor at the Universities of Szeged and Kolozsvár. He died 15 years ago. The authoress was one of his students.

mer (Omladék Valley, pn. stocki Cubryny), and yellowish-green snow in the side of the Tengerszem Peak (Rysy, ph. sbocza Rysow; ROSTAFINSKI, 1881; 1927; GUTWINSKI, 1909).

According to the literature, those mentioned above were the first to have observed coloured snow in the High Tatra; however, they had not yet known the microorganisms of the discolorations. ROSTAFINSKI was the first to identify the algae of the red snow. Several other alpinists and botanists had also collected coloured snow in the Tatra Mountain; to mention only a few: I. and B. GYŐRFFY, A. GROSZ, M. S. SOKOLOWSKY and E. KOL, J. SIEMINSKA, W. PARYSKI, and others.

Collection localities (Snow samples)* 1. Kepy valley (Kepy dolina), below the Lastowica rock (Schwabelberg Belaer Kalkalpen, Tatrach Bielskich, Belanske Tatry, Photograph 3, altitude 1340 m, pH 6.5—6.0, leg. I. GYŐRFFY et KOL 26. 8. 1926, 16. 7. 1927, 16. 7. 1932, 23. 7. 1934; green and black snow, in I. GYŐRFFY 1927, 1927a, KOL 1927, 1927a, 1928, 1949, 1968; leg. 2. 6. 1960 in KOMAREK—HINDÁK—JAVORNICKY 1973.

* 2. Trümmer Valley (Omladék-völgy), below the Western Eisenentor, Iron Gate Peak (Puszta dolina, Dolina Zlomisk, powzej Zmarzlego staw Photograph 2) altitude 2100—2200 m, pH 5.5—5.4, red snow, leg CHALUBINSKY 11. 7. 1876, I. GYŐRFFY et KOL 9. 7. 1927, 21. 7. 1932, in I. GYŐRFFY 1928, KOL 1928, 1949, in mscr., ROSTAFINSKI 1881, 1927.

* 3. Gross Papyrus valley by waterfall, Dzikiej dolina Zelena pleso, below the Miedzana lafka (Photograph 8), altitude 1700—1920 m, black snow, leg. I. GYŐRFFY 17. 8. 1909 in SCHERFFEL 1910, KOL 14. 8. 1924, 23. 8. 1927, in KOL 1920, 1968. leg. HINDÁK 2. 8. 1963, in HINDÁK 1969.

3a. Valley of the Green Lake of Késmárk (Valley of the Késmárker Grüner See, Késmárki Zöld tó völgye) below the Késmárk Peak, Valley of the Zelena plesó, below the "Deutsche Leiter" (Photograph 8), altitude 1600—1710 m, pH 5.5, black snow from different places leg. KOL 14. 8. 1924, 20. 7. 1938, in KOL 1967, in KOL mscr.

* 4. Frost Lake (Gefrorener See), in Poduplasky Valley, altitude 2046 m, leg. Kol 25. 7. 1926, in KOL 1928, KOL mscr.

5. Trystarska Valley (Triscarka Dolina Trzystarska Dolina) green snow pH 6.5—6.0 (Photograph 6), altitude 1800 m, leg. KOL 20. 8. 1927, 10. 7. 1932, in KOL 1949, KOL mscr.

* 6. Valley of the Green Lake of Késmárk (Valley of the Késmárker Grüner See), below the Blauen See (Blue Lake), alt. 1900—2100 m black snow from different places leg. KOL 14. 7. 1924, 29. 7. 1927, in KOL 1967, KOL mscr.

* 7. Rysy peak (Tengerszem csúcs, Meeraug Spitze) alt. 2300 m black snow, leg. 25. 9. 1938, KOL in mscr.

* 8. Kleine Kolbach Valley (Kis Tarpataki völgy), Five Like (Kis Tarpataki Öttó) in the Tarpatak Valley, alt. 1990 m. leg. KOL 20. 7. 1927, leg. R. Roth, in Scherffel 1904, KOL 1949, in KOL mscr.

* Material of the collections marked with an asterisk is obtainable in KOL's snow algae collection.

* 9. Below the Wilderer Joch (Vadorzó hágó, Korickowa Pass, Goriczkowa Pass) leg. R. SZALÓKY, R. ROTH in SCHERFFEL 1904, KOL 8. 8. 1926, KOL 1948, KOL in mscr.

* 10. Döller Lake alt. 2000 m pH 5.5—5.2, red and pink snow (Photograph 7), leg. B. GYŐRFFY 22. 7. 1932, KOL 27. 7. 1934, in KOL 1965, 1968.

11. Morskie Lake (Morskie Oko) Morskiego Oko Fisch See Mienguszowskiegó scetu and Morskiem Okiem alt. 1500 m, in the flake of an old snow beneath the Mienguszowski Peak, above Morskie Oko, leg. SIEMINSKA 19.10. 1950. KOL 13. 7. 1965, KOL 1966, SIEMIENSKA 1951, PARYSKI 1951.

* 12. Valley of the Green Lake of Késmárk (Késmárker Grüner See Tal), from different places (Photograph 8), alt. 1600, 1700 m black snow (Photograph 5), pH 5.5, leg. KOL 14. 8. 1924, 29. 7. 1927, 20. 8. 1938, in KOL 1967, KOL mscr. yellow-brownish snow 1600 m, pH 5.1, the Medené lavky, leg. 2. 8. 1963, HINDÁK, in HINDÁK 1969.

* 13. Below the Toten Garten in the cirque Valley of the Steinbach Lake above the Steinbach Lake (Kőpataki tó), black snow, pH 5.5, leg. KOL 20. 7. 1938, 22. 8. 1925, in KOL mscr.

* 14. Above the Hunfalvy hágó (Huncdorfer Pass, Huncowske Szcyt) black snow alt. 1800, 2010 m, pH 5.5, leg. KOL 3. 8. 1924, 24. 7. 1938, in KOL mscr.

* 15. Above the Frog Lakes (Békás tavak, Frosch Seen, Zabie plesó), black snow (Photograph 4), alt. 1920 m, pH 5.5, leg. I. GYŐRFFY 9. 1910, KOL 26. 7. 1938, in SCHERFFEL 1914, KOL in mscr.

* 16. Handel Valley, Valley of the Green Lake of the Kriván, Krivanske black snow, leg. KOL 23. 8. 1938, in KOL mscr.

* 17. Valley of the Buchholtz Lakes alt. 1880 m, black snow, leg. KOL 24. 7. 1925, in KOL mscr.

* 18. Below the Gemsen Peak (Zerge csúcs, Kozie Vierch), alt. 1820—2000 m, leg. KOL 23. 7. 1926, from different places in KOL mscr.

* 19. Below the Lomnitz Peak (Lomnitzer Spitze, Lomnici csúcs) Lomnica, alt. 2300, 2400 m, 750 m, from different places, black snow, leg. KOL 12. 8. 1925, in KOL mscr.

* 20. Below the Eistaler Peak (Jégvölgyi csúcs), Valley of the Five Lakes, alt. 2250, 2300 m, black snow, leg. KOL 14. 7. 1938, in KOL mscr.

* 21. Krywanskie Kryto, Kotliny Krivanske (Krivaner Kesseltal), cirque on the NW slopes of Krivan (napa zach stockach Kryvania), 1500 m, red snow leg. W. PARYSKI 3. 10. 1967, in KOL 1969.

22. Mienguszovski Valley (Kotle Mienguszowkiem), Mienguszovski cirque, alt. 2000 m, leg. SIEMINSKA 8. 8. 1952. in SIEMINSKA 1956.

23. Below the Szpiglasova pass on the side of Five Lakes (Picé Staw, OW "Spiglasowweh Perciach", pod Przelecza Spiglasova), alt. 1960 m, leg. W. PARYSKI 20. 8. 1938, in SIEMINSKA 1951.

24. Pn. Stoky Cubriny yellow snow, leg. ROSTAFINSKI, in ROSTAFINSKI 1881, 1927, GUTWINSKI 1909.

25. Valley za Mnichem, slope of Cubrina Mönch, yellow snow, leg. STARMACH et KAWECKA 12. 9. 1962, in STARMACH et KAVECKA 1965.

26. Temnosmrečanské Dolina na uzemi "Snehovy Kotol pod Cubrinon" alt. 1773 m, leg. POSPISIL 1947, in POSPISIL 1950.

27. Below the Rysy Peak (Tengerszem csúcs, Meeraug Spitze, pn. Zborcza Rysowa), yellow snow, leg. ROSTAFINSKI, in ROSTAFINSKI 1881, 1927, GUTWINSKI 1909.

28. Granaten Wall in Felka Valley (Granaten Wand in Felka Valley), black snow, in many places, leg. R. SZALÓKI, I. GYŐRFFY 1910, leg. HIERONIMUS 1888, in RICHTER Phycotheka Universalis Nr. 334.

* 29. Mlinica valley above the Schleierwasserfall (Fátyolvízesés), black snow, leg. KOL 27. 7. 1934, in KOL mscr.

30. Under the Batisfalva lake (Batisowské pleso) under a waterfall on the peaty bank of a mountain torrent originating from the lake "Batisovské pleso", leg. RUZIČKA 8. 8. 1957, alt. 1800 m, in MARVANOVA—MARVAN—RUZIČKA 1967.

31. Velka Zmrzla Dolina, Tatris Altis cc. 2000 m, green and red snow, leg. 1966, JAVORNICZKY and HINDÁK.

Coloured cryoseston

In the High Tatra there has been detected red, pink, yellowish-green yellowish-brown, yellow, green, blue and black cryoseston discolorations; and two kinds of *Chlamydomonas* red snow, namely, that caused by *Chlamydomonas nivalis* (Bau.) Wille (Pl. I. Figs 9—16), and by *Chlamydomonas sanguinea* Lagerh. (Pl. I. Figs 42—47). Red snow, caused by *Chlamydomonas nivalis*, is most frequent not only in the High Tatra, but also in Europe, and even in the whole northern hemisphere.

ROSTAFINSKI was the first to identify the microorganism of the red snow in the High Tatra (ROSTAFINSKI, 1881; see Table 3).

Subsequently, red snow was collected from a number of mountains in Europe, and by laboursome work, the microorganism causing red snow became known and assigned to its systematical place (CHODAT, 1896; WILLE, 1903). Today we know it under the name *Chlamydomonas nivalis* (Bau.) Wille (see Table III). (KOL, 1968).

The second period of cryobiological researches in the High Tatra actually began with ROSTAFINSKI's activities. A number of workers study today the cryovegetation of the High Tatra (for details see Table 3).

Red snow caused by *Chlamydomonas nivalis* are known from several places in the Tatra Mountains. One of the typical localities of red snow is the

Omladék Trümmer (Valley) (Photograph 2), below the Western Iron Gate Pass, at an altitude of 2100—2200. First CHALUBINSKY observed red snow here in 1872, then ROSTAFINSKI in 1880, and GYŐRFFY and KOL in 1927, 1932.

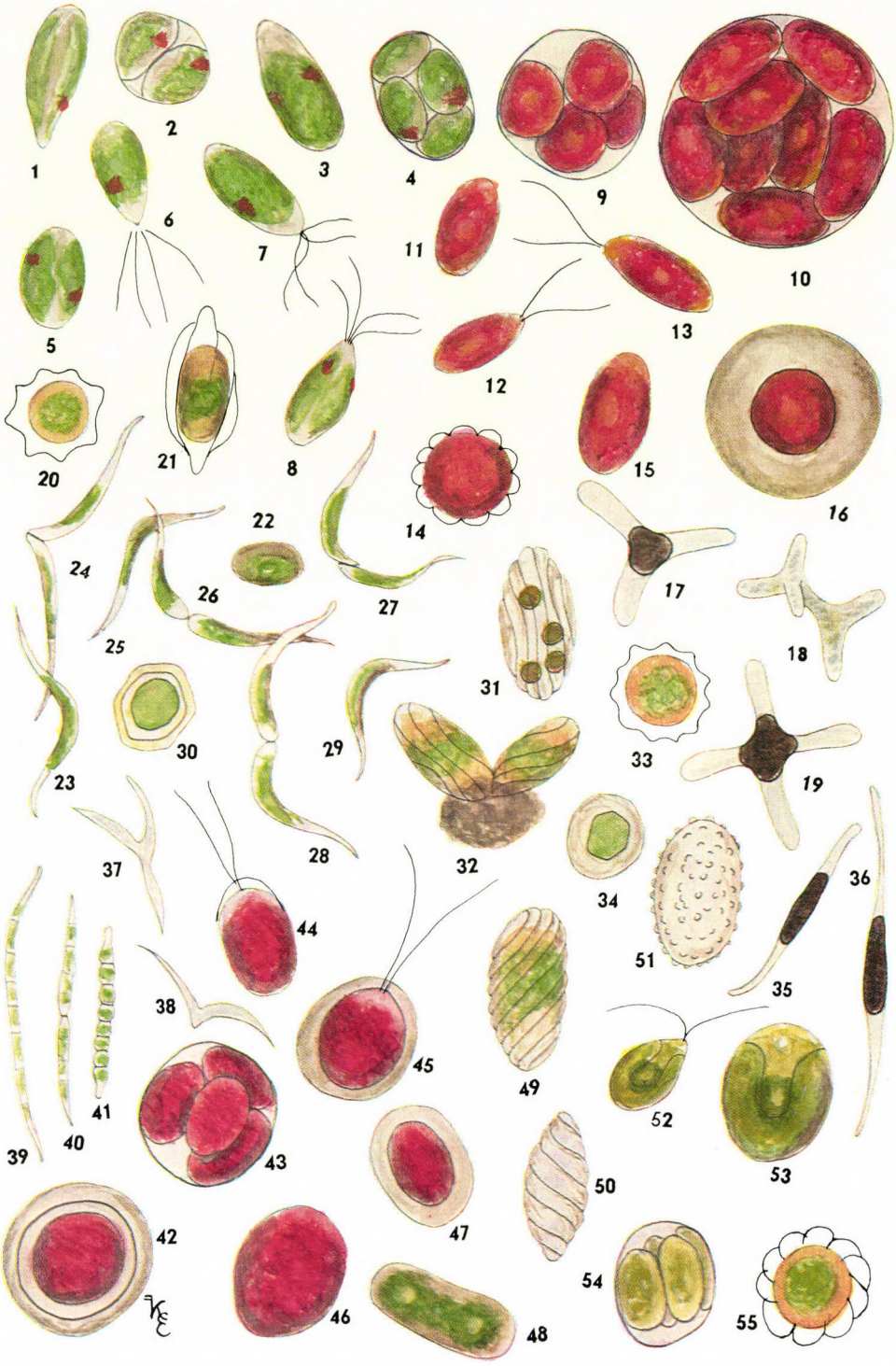
Today the microorganism association of this red snow is known in detail (see KOL 1928). The mass of the red snow in the Omladék Valley (Trümmer Tal, Locality No. 2) was composed of *Chlamydomonas nivalis*. The spherical, resting stage cells were represented in the largest quantity. Beside them the following microorganism lived there in a smaller or larger number of individuals but within these always in a small quantity only. *Chroococcus rufescens* (Bréb./Näg. *Chr. scherffelianus* Kol, *Gloeocapsa sanguinea* (Ag.) Kg., *Gl. ralfsii* (Harv.) Lemm., *Petalonema densum* (A. Br.) Näg., *Nostoc fuscescens* Fritsch, *Scotiella nivalis* (Shuttlew) Fritsch (Pl. I. Figs 20, 21), *Scotiella cryophila* Chod., *Raphidonoma bervirostre* Scherf. (Pl. I. Fig 41), *Győrffyella tatrica* Kol-*Gyoerffyella rotule* (Hőhn.) Marvanova, *Cosmarium subspeciosum* var. *schaarschmidtianum* Kol (KOL 1928) (see Table III).

As is to be seen, the algal association of the red cryoseston in the Omladék Valley is rather rich. Not only alpine species can be found there, but also arctic-alpine and even arctic algal species. Numerous cryoxenous species also live there, which arrive at the surface of the snow from the neighbouring rock walls.

Chlamydomonas red snow exists not only on the snow surfaces of the Trümmertal, but also in several other localities of the Tatra Mountains (see Table III).

One of the cryobiological specialities is the red snow, caused by *Chlamodymonas sanguinea* Lagerh., collected by W. PARYSKI in the Kriván Tátra, Locality No 21. Stanowisko Kryvinskia (Krivaner Kessel, Cirque), alt. 1950 m. In this red snow *Chlamydomonas sanguinea* (Pl. I, Figs 42—47) predominated. Besides this, *Chlamydomonas nivalis* (Bau.) Wille (Pl. I, Figs 9—16), *Scotiella norvegica* Kol f. minor Kol (Pl. I, Figs 49, 50, 55), *Pleurococcus vulgaris* var. *cochaerens* Wittr., *Koliella tatrae* (Kol) Hindák (Pl. I, Figs 23—26), and *Romeria cryophila* Kol, lived in the red snow there. The colour of this snow is sanguineous (KOL, 1969).

A pink cryoseston was first observed on the snow cover of the ice of the Döller Lake, at an alt. of 2000 m (Photograph 7), by BARNA GYŐRFFY in 1932 (see Locality No. 10). KOL also saw and collected pink-coloured snow here in 1932. In this pink snow *Scotiella tatrae* Kol (Pl. I, Figs 23—29), dominates, but *Chlamoydomonas nivalis* (Bau.) Wille also lives there in a rather large quantity. It is the mass of *Scotiella tatrae* which causes the pink shade of the snow; when, however, *Chlamydomonas nivalis* appears in greater masses, the snow is of a reddish colour. In addition, also *Scotiella nivalis* (Shuttlew) Fritsch (Pl. I, Figs 20, 21), and *Chionaster bicornis* Kol (Pl. I, Figs 35, 36) lived in this pink snow (KOL 1968) (see Table 3).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Yellow and green snows belong to the rare cryoseston colourations. In the Tatra Mountains, ROSTAFINSKI was the first to mention yellow snow. Zboc za Rysova, Omladék Valley, Puszta dol. (Locality Nos 2 and 27); this yellow snow was caused by *Chlamydomonas flavovirens* Rostafinski. This species is rather rare in the Tatra Mountains.

A yellowish-green cryoseston was found on the snow surfaces of the Za Mnichem Valley (see Locality Site No. 25), by STARMACH and KAVECKA. This yellowish-green snow was caused by the mass occurrence of *Chlamydomonas rostafinskii* Starmach et Kavecka (Pl. I, Figs 51—54). Besides this, *Chlamydomonas nivalis* (Bau.) Wille, *Scenedesmus* cf. *bijugatus* (Turp.) Kg., *Ancylonema nordenskiöldii* Berggr., *Gloeocapsa turgida* (Kg.) Hollerbach (Starmach et Kavecka 1965) also lived there. (The characteristic alga of ice fields, *Ancylonema nordenskiöldii* Berggr., *Gloeocapsa turgida* (Kg.) Hollerbach (Starmach et Kavecka 1965) also lived there.) The characteristic alga of ice fields, *Ancylonema nordenskiöldii* Berggr., is so far unknown from the snowfields of the High Tatra. Although I have examined many snow samples from very different places of the Tatra Mountains, I have never found the cells or filaments of *Ancylonema nordenskiöldii*. It would be interesting to pay greater attention to the occurrence of *Ancylonema nordenskiöldii* in the High Tatra. Let me note here that microphotograph (b) in STARMACH—KAVECKA (1965: 78) greatly resembles a dividing *Cylindrocystis* cell.

A rarer natural phenomenon in the Tatra Mountain is the green cryoseston. Green snow is a characteristic snow of the Béla Limestone Alps. Two

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Explanation to Plate I

Figs. 1—8 Carteria gyoerffyi Kol (×1000); 1, 3, 5: nonmotile cells; 2—4: cell division 5—8: zoospores, vegetative cells

Figs. 9—16 Chlamydomonas nivalis (Bau.) Wille (×1000); 11—13: zoospores, vegetative cells; 9, 10: cell division; 11: zoosporangium; 14: young zygote; 15: non-motile cell; 16: resting stage, with very thick gelatinous sheath

Figs. 17—19 Chionaster nivalis (Bohl.) Wille (×1000); 18: young individuum

Figs. 20—21 Scotiella nivalis (Shuttlew.) Fritsch (×1000); 20: transversal section

Fig. 22 Mesotaenium berggrenii (Wittr.) Lagerh. (×1000)

Figs. 23—29 Koliella tatrae (Kol in Győrffy) Hindák (×1000); 23, 25, 29: diversely curved cells; 24, 26—28: different stages of cell division

Figs. 30, 34 Tetraedron valdezi Kol (×1500)

Figs. 31—33 Scotiella tatrae Kol (×1000); 33: with four spores; 32: young cells; 33: transversal section

Figs. 35, 36 Chionaster bicornis Kol (×1000)

Figs. 37, 38 Selenotila nivalis Lagerh. (×1500)

Figs. 39, 40 Raphidonema nivale Lagerh. (×1000); 40: division of the filament (×1500)

Fig. 41 Raphidonema brevirostre Scherffel (×1000)

Figs. 42—47 Chlamydomonas sanguinea Lagerh. (×1500); 42: resting stage with very thick gelatinous sheath; 43: cell division; 44, 45: motile cells, zoospores; 46: giant cell (×1000); 47: non-motile cell with gelatinous sheath

Fig. 48 Cylindrocystis brébissonii var. *cryophila* Kol (×1000)

Figs. 49, 50, 55 Scotiella norvegica Kol (×1000); 55: optical view

Figs. 51—54 Chlamydomonas rostafinskii Starm. et Kavecka; 51: zygote; 52: zoospore, motile cell; 53: non-motile cell; 54: cell division

kinds of green snow are known from that locality. *Koliella* green snow and *Carteria* green snow. The locality of the *Koliella* green snow is the Kepy Valley (Kepy dolina) (Photograph 6) (Locality No. 1), where immeasurable masses of *Koliella tatrae* (Kol) Hindák (Pl. I, Figs 23—29) causes the green colour of the snow. But it causes the green colour of not only the surface of the snow, but the snow is green in many cases to depths of several cm (see GYŐRFFY, 1927c; 1927d; KOL, 1968).

In this green snow, a rather rich algal community appears together with *Koliella tatrae* (Kol) Hindák (Pl. I, Figs 23—29), the following microorganisms can be found here: *Aphanocapsa nivalis* Lagerh., *Gloeocapsa kützingiana* Näg., *Gl. ralfsii* (Harv.) Lemm., *Gl. alpina* Näg. am Brand, *Scytonema minor* (Schmidle) Lemm., *Phormidium frigidum* Fritsch, *Tortiella scrobiculata* Pascher, *Chionaster nivalis* (Bohl.) Wille (Pl. I, Figs 17—19), *Ankistrodesmus longissimus* var. *Rostafinskii* Kol, *Gyoerffyella tatrica* Kol-*Gyoerffyella rotula* (Hőhn.) Marvanova, *Ulothrix flaccida* Kg., *Selenotila nivalis* Lagerh. (Pl. I, Figs 37, 38). In 1963, HINDÁK also collected green *Koliella tatrae* (Kol) Hindák snow there (Pl. I, Figs 23—29), and also succeeded to establish its pure culture.

GYŐRFFY and KOL collected *Carteria* green snow in 1927 and 1932 in the Bela Limestone Alps, in the Trystarska (Triscarska Dolina) Valley between the Greiner and the Havran Peaks (see Locality Site No. 5; Photograph 7) at an alt. of 1800 m. The pH value of the snow was 6.5—6.0. The green seston colour caused by the huge amount of *Carteria gyoerffyi* Kol (Pl. I, Figs 1—8). In the company of *Carteria*, also the following microorganisms occured in smaller or larger quantities. *Pleurococcus vulgaris* var. *cohaerens* Wittr., *Tetraedron valdezi* Kol (Pl. I, Figs 30, 34), *Koliella tatrae* (Kol) Hindák (Pl. I, Figs 23, 29), *Chionaster nivalis* (Bohl.) Wille (Pl. I, Figs 17—19), *Chionaster bicornis* Kol (Pl. I, Figs 35, 36) (KOL 1949, 1968, KOL in mscr.).

In the summer of 1963, HINDÁK collected yellowish-brown snow at an alt. of 1600 m in Zeléného plesó prope Medené lávky (Locality No. 3); he succeded to obtain a pure culture in vitro of the microorganism. This brownish yellow snow was caused by the mass of *Chromulina ettlii* Hindák (HINDÁK, 1969).

Blue-coloured snow is very rare. The microorganisms of only very few blue-coloured cryosestons are known (KOL 1968). There is only one literature data on the blue snow of the High Tatra. In 1872 CZIRBESZ saw blue-coloured snow in the Poduplaski Valley, Svistovka Dolina (Gefrorener See) at altitude 2047 m (see GYŐRFFY, 1927; PARYSKI, 1951). The microorganisms of this blue-coloured snow are, however, not known.

The most frequent coloured snow in the Tatra is black snow (Photograph 5). It was only in a very few other mountains that I found snow of such black colour as the one of the Tatra. It can be said that black snow is the characteristic coloured snow of the Tatra, or more generally of the European

mountains. The details of the causes of black snow are not yet known. Very likely it is partly caused by strong carbonization and by various *Chlorobacteria* and other bacterial species.

Very little is still known about the life conditions, the causes and conditions of the mass distribution of nivicolous microorganisms. This is also one of the reasons why cryoseston discolourations brought under the microscope of research workers.

pH measurements

The third period of cryobiological researches actually began when the attention of researchers began to extend to also the physical and chemical characteristics of biotopes, and experiments were carried out to obtain microorganisms in cultures of laboratories.

I began pH measurements first in the area of the High Tatra and in the Bela Limestone Alps, in 1932, then in the Swiss Alps in 1933, and again in North America on the snow fields and glaciers of the Rocky Mountains and of Alaska in 1936.

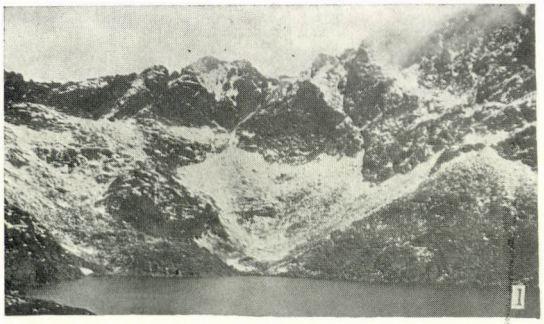
The results of pH measurements based on several hundreds of measurements taken for some years in the High Tatra, are included in Tables 1 and 2. In the High Tatra pH measurements were taken *in situ* in each case, with the help of a Hellige comparator, every year in July and August in 1932, 1934, 1935, 1938.

As can be seen in Table 1, pH values are not identical at various depths and on the surface; a difference of a few decimals always occur. The pH value

Table 1

pH of snowfields

Locality of the snowfields	Altitude, m	Colour	pH on surface	pH at 10 cm
High Tatra — Granite Tatra				
Great Papyrus Valley, Dolina Dzika by waterfall	1700	black	5.5	5.2
Great Papyrus Valley, Dolina Dzika	1650	black	5.4	5.2
Valley of the Green Lake of Késmárk	1600	black	5.5	5.2
Below the Késmárk Peak	1700	—	5.4	5.2
Below the Késmárk Peak	1650	—	5.5	5.2
Trümmer Valley, Dolina Zmisk	2100	red	5.5	5.2
Mlinica Valley below the Schleier waterfall	1770	—	5.4	5.2
Valley of the Frog Lake	—	black	5.5	5.3
Skok Lake snow	—	—	5.4	—
Ice Lake snow	1920	—	5.4	5.2
Meeraug Peak, Rysy	2000	—	5.2	5.0
Hunfalvy Pass	—	—	5.2	5.0
Döller Lake, snow	2000	red pink	5.2	5.0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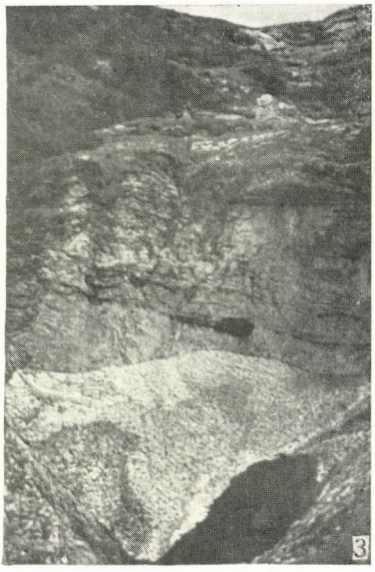
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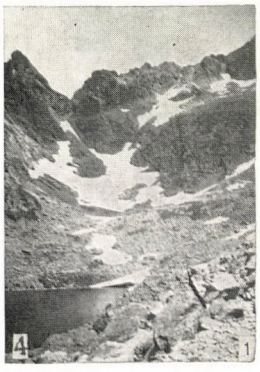
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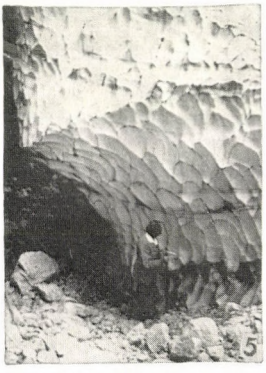
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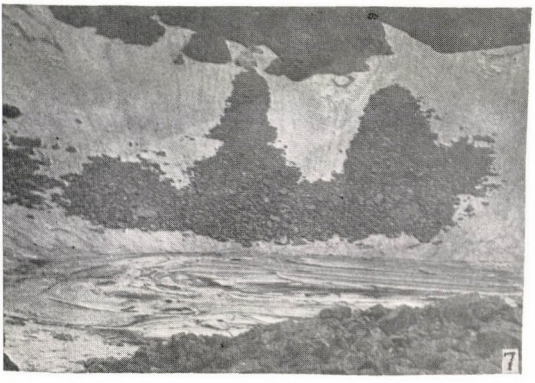
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Table 2

pH of snowfields at different depths

Locality of snowfields	Altitude, m	Surface	pH at different depths of the snow, cm				
			5	10	20	30	50
High Tatra — Granite Tatra							
Trümmer Valley, Dolina Zmisk red snow	2180	5.4 5.5	5.2	5.2	5.2	5.2	5.0
Great Papyrus Valley, Dolina Dzika	1700	5.5 5.4	5.2	5.2	5.2	5.0	5.0
Bela Limes Alps — Tatrach Bielskich							
Kepy Valley, Dolina Kepy green snow	1420	6.5	6.2	6.0	6.0	—	—
Tryskarska Valley, Tryskarska Dolina green snow	1800	6.5	6.2	6.2	6.0	—	—
Tryskarska Valley, Triskarska Dolina green snow	1740	6.5	6.2	6.0	5.9	—	—

of the Trümmer Tal red snow is 5.5, 5.4 on the surface while at a depth of 5 cm it is 5.2, and at a depth of 50 cm it is only 5.0. The same holds for the pH values measured in the Papyrus Valley.

In the Bela Limestone Alps, the pH value of the snow surface was 6.5, at a depth of 10 cm it was 6.2 and at 20 cm it was only 6.0 (Table 1).

Table 2 gives the results of the measurements carried out in several areas in the Granite Tatra. It is clear from the measurements, taken far from each other, and at various altitudes, that the pH value of the snow surface in the granite field was 5.5—5.4, at 10 cm it decreased to 5.2, and sporadically even to 5.0.

Explanation to Plate II

Photograph 1 Trümmer Valley, Omladékvölgy, Dolina Zmisk, Puszta Dolina, Lowland Plain Dolina, alt. 2000—2100 m; the locality of *Chlamydomonas nivalis* red snow (Locality No. 2)

Photograph 2 Frog Lakes, Zabile stawu, Békás tavak; above the Lake, below the Simon tower, red snow spots (Locality No. 15)

Photograph 3 Hinzen See, Lake and Cubrina Hincové Pleso v. pozadu Cubrina

Photograph 4 Trystarska Valley, Trystarska Dolina, between the Greiner and Havran peaks; the locality of *Carteria gyoerffyi* Kol (Locality No. 5)

Photograph 5 Black snow of a snow-gate in the valley of the Késmárk Green Lake below the Késmárk peak

Photograph 6 The Great Papyrus Valley in the valley of the Késmárk Green Lake; the snow field below the fall is the original locality of *Raphidonema brevirostre* Scherffel; top: Miendzana Lafka (Localities Nos 3, 3a, 6 and 12)

Photograph 7 Döller Lake with pink snow; the locality of *Scotiella tatrae* Kol (Locality No. 10)

Photograph 8 The original locality of *Koliella tatrae* (Kol) Hindák, in the Béla Limestone Alp, with *Koliella tatrae* green snow (Locality No. 1)

It appears from the pH measurements (Tables I and II) that pH values 5.5—5.4 are characteristic of the snow surface in granite areas, while in the Bela Limestone Alps higher pH 6.5—6.0 values are characteristic.

My results obtained on the basis of pH measurements in the Alps and in North America were similar.

In the mountains composed of acidic rocks, the pH value of the snow surfaces is 5.5—5.2, while in mountains containing limestone the pH values of snow surfaces are 6.5—6.0. The characteristic coloured snow of the latter areas is green snow. It also follows from this that the microorganisms of the green snow are calciphilous. The characteristic coloured snow of the mountain consisting of acidic rock is red snow.

I have made this statement with reference to the areas in which I have carried out researches. Naturally, if some outside effect influences the snow surface, the value of the highly sensitive pH may vary. The influencing factor is not the circumstance whether the snow lies on granite or on limestone rocks, but the quality of the mineral matter falling from the surrounding rock walls on to the snow surface and solving there at times in the water of the thawing snow. Then, naturally, it serves as a nutrient for the nivicolous microorganisms. The various micro-organic species settle on the diverse cryobiotopes, according to their nutrient requirements. Several authors took pH measurements in the High Tatra: HINDÁK (1970), JAVORNICZKY (1970); in the Antarctic: H. FUKUSHIMA (1959), and E. G. FOGG (1967); in North America: W. TOMASON (1969) in California and in Sierra Nevada R. K. GARRIC (1965), in the Olympic Mountain, in the Mt. Rainer Nat. Park and in the neighbouring mountains and also in the Carstens Mountain in New Guinea; J. A. PETERSON in the Spitzbergen; and S. EUROLA in Finland.

The second part follows in the next number.

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DISTRIBUTION AND DYNAMICS OF PHOSPHORUS, NITROGEN AND POTASSIUM IN PERENNIAL OPEN SANDY STEPPE-MEADOW

(FESTUCETUM VAGINATAE DANUBIALE)

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We examined the seasonal dynamics of P, N and K in the various phytomass fractions and the soil parallel with the seasonal dynamics of the phytomass in perennial open sandy steppe-meadow — *Festucetum vaginatae* danubiale — which is characteristic of and generally spread on the sandy soils in the Danube—Tisza Mid-Region. The plant matter and soil of the 22 monolith samples of $20 \times 20 \times 20$ cm, taken monthly in 1971, was elaborated.

It could be inferred that in the phytomass, in its individual fractions, the concentration of nitrogen is the highest, potassium is lower then that, while the concentration of phosphorus is about one order smaller. All the three elements occur in highest concentration in the living parts. The decrease in nitrogen concentration shows an order of living aboveground parts, dead aboveground parts, and roots. In the case of potassium and phosphorus, the order of decrease in element concentration is aboveground parts, roots, dead aboveground parts.

The concentration of all the three elements examined is much lower in the soil. The bulk of the nutrients accumulated in the phytomass occurs in the belowground parts. The total phytomass of the perennial open sandy steppe-meadow contains about 100 kg nitrogen, 30 kg potassium and 7—8 kg phosphorus in an area of 1 hectare. The total nitrogen content of a suitable stratum of soil — 20 cm thickness in an area of one hectare — is about 1000—1200 kg, its total potassium content is 3000—3200 kg; its total phosphorus content is of a value around 300—500 kg. The available quantities of the nutrients are about 12 kg nitrogen, 150 kg potassium and 30 kg phosphorus.

In the soil-plant system examined, a varying proportion of the elements are under biological control, that is, 10% of total nitrogen, 3% of total phosphorus and about 1% of potassium.

In the case of nitrogen, the ratio between the stores of elements that can be incorporated and those that are accumulated in the phytomass indicates that the presence of available nitrogen in the soil can restrict the quantity of N actually incorporated in to the organic matter, and so the production itself, as a minimum factor.

Introduction

In the framework of the International Biological Program (IBP) the examination into the turnover of the mineral matter of ecosystems has come to the foreground. The researches attempt to follow the methodology of system analysis (POMEROY, 1970), and clarify the element spectrum of the biological cycle, the quantity of mineralomass, the volume and speed of circulation

(BASILEVICH–RODIN, 1971; BASILEVICH, 1973). These parameters assume a rather varying pattern in the various plant formations covering the earth surface.

Investigations into the mineral matter distribution and seasonal dynamics of grassland communities dry steppes, sandy meadows have been carried on by several especially Soviet researchers (BASILEVICH, 1965; BOGDANOV, 1970; 1971; KARPOV, 1958; TURINA—ZEINALASVILI, 1965; FARTUSHINA, 1971; BASILEVICH, 1973; JAKRLOVÁ, 1972; ULEHLOVÁ, 1972 etc.), and the general review concerning the whole earth surface is also associated with the names of Soviet authors (BASILEVICH—RODIN, 1969; 1971).

In Hungary, the examination into the distribution, and seasonal dynamics of the three most important nutrients P, N and K has been set as a purpose related to the phytomass examinations taking place within the IBP/PT section. This question is especially important in relation to sandy soils and their vegetation, since 24% of the area of our country is sand field, which from the viewpoint of the national economy bears great importance both in its original and cultivated states.

Material and methods

Our examinations were carried out in the Danube—Tisza Mid-Region in the IBP sampling area of Csévharaszt, in 1971. (For the characterization of the *Festucetum vaginatae* danubiale plant community see KOVÁCS-LÁNG, 1970; SIMON, 1971; KOVÁCS-LÁNG—SZABÓ, 1971; VERSEGHY—KOVÁCS-LÁNG; 1971).

For the purposes of the examinations, 22 contiguous long rectangle-shaped areas soil monolith of $20 \times 20 \times 20$ cm, were taken monthly out of the characteristic stand of perennial open sandy steppe-meadow. The following fractions were separated from the phytomass of the samples: the aboveground living material of *Festuca vaginata*, and of other flowering plants (*Potentilla arenaria*, *Koeleria gracilis*, *Medicago minima*, *Alkanna tinctoria*, *Polygonum arenarium*), total flowering aboveground dead phytomass, moss-lichen phytomass (e. g. *Cladonia magyarica*, *Cl. furcata*, *Parmelia pokornyi*, *Cl. convoluta*), and belowground plant parts. By using wet digestion techniques in concentrated H_2SO_4 (after KJELDAHL's method) in the plant matter of the phytomass fractions owing to their small weight, four of them were taken as one sample the potassium content was determined by means of flame photometry, the nitrogen and phosphorus by colorimetry.

In order to determine the total N content of the soil the material was digested in concentrated H_2SO_4 and after distillation the N was measured by titrimetry. The determination of total and soluble potassium content was carried out by flame photometry, that of absorbable phosphorus by colorimetry after extraction by an ammonium lactate solution.

Results and discussion

The dynamics of phosphorus

The phosphorus concentration in the phytomass fractions is shown in Table 1. P-concentration is the highest in the living aboveground floral parts, and within this, in the "other flowering" fractions consisting mainly of dicotyledons. The P-content of the roots is substantially lower than that of the aboveground living parts, it amounts to 70% of that (related to the aboveground living parts of *Festuca vaginata*). The dead parts of the flowering plants which the steppe meadow consist of show the lowest P-concentration. The P-content of the moss-lichen fraction is also a low value being near to that of the latter flowering fraction. The phosphorus content values determined by us for the phytomass fractions show satisfactory correspondence with those measured in wild-growing plants of the country (SIMON—TÖLGYESI, 1969).

According to our investigations, the phosphorus concentration of the individual phytomass fractions show a fluctuation of various extent during the vegetation period. The fluctuation is of lowest extent in the P-content of the roots, which amounts only to 15% of the maximum value. That of the aboveground dead floral parts is about 17%, and in the aboveground living parts of *Festuca vaginata* is about 18%. The cryptogamous fraction shows fluctuation of about 20%. In comparison with the other fractions, the seasonal fluctuation in the P-concentration in the aboveground other flowering phytomass fraction is remarkably high, amounting to about 48%. The probable reason for this may be that the species composition of the "other flowering" fraction changes with the changes in the aspects of the steppe meadow in the

Table 1

Total phosphorus concentration of the phytomass fractions in Festucetum vaginatae danubiale grassland, mg %

1971	IV.	V.	VI.	VII.	VIII.	IX.	X.
Aboveground living matter of *Festuca vaginata*	92.68	98.66	84.00	84.16	92.00	89.66	102.66
Aboveground living "other flowering" parts	171.56	120.38	101.72	125.62	151.84	89.51	148.64
Aboveground dead flowering phytomass	59.00	51.66	53.33	55.53	62.00	54.33	55.66
Moss-lichen phytomass	54.33	50.86	59.66	61.66	63.66	55.00	62.86
Belowground phytomass	69.53	65.33	60.66	63.66	69.86	61.00	60.66
Soluble phosphorus concentration of the soil	0.87	0.87	1.05	1.05	0.96	0.87	1.53

course of the vegetation period, therefore, the phytomasses of plant species were variably dominating in the materials coming under investigations from the various periods. The picture is complicated by the fact that the P-content of the various species — according to their phenophase — also changes with time.

The phosphorus concentration of the aboveground living part of the dominant *Festuca vaginata* shows a minimum in the period of production maximums. The changes in P-concentration of the belowground phytomass consisting mainly of the rootparts of *Festuca* follow a similar course. It is only in the autumn period when a difference is found, i.e. the P-content of the living aboveground parts increases considerably, while that of the roots decreases.

The absorbable P-concentration in the soil of the monoliths, which can be determined by extraction with ammonium lactates, is of a low value in relation to that of plant materials. It is characteristic of its seasonal variation that in opposition to the decrease found in the living plant parts in the first half of the vegetation period, its quantity tends to increase.

The absolute maximum of the available P-content of the soil occured in October, when the intensity in the nutrient uptake of the vegetation decreases. The available phosphorus content of the soil is very small in thin sand soils, but the total P-content is not a high value either (10—50 mg%). The quantity of the available phosphorus is decreased owing the high $CaCO_3$ (1.5—3%; pH 7.0—7.2) and SiO_2 content, which bind the phosphorus compounds in a dissoluble form.

By knowing the weight and phosphorus concentration of the phytomass fractions the quantity of the phosphorus accumulated in the phytomass and soil volume of a unit area can be determined (Table 2). It can be seen that the quantity of the phosphorus contained by the monolith is determined above all by the phytomass volume. For example in June is as follows: in the aboveground living parts of *Festuca vaginata* there is 0.232 kg P/ha, in that of "other flowering plants" 0.032 kg/ha; in the dead aboveground phytomass there is

Table 2

The quantity of phosphorus accumulated in of monoliths (mg/monolith) and its distribution in the phytomass

	IV.		V.	
	mg	%	mg	%
Aboveground living material of *Festuca vaginata*	0.49	1.33	1.04	3.26
Aboveground living "other flowering" parts	0.33	0.90	0.22	0.69
Aboveground dead flowering phytomass	4.18	11.34	3.85	12.10
Moss-lichen phytomass	2.63	7.16	2.62	8.24
Belowground phytomass	29.19	79.28	24.12	75.71
Total plant phosphorus	36.83	100.00	31.86	100.00
Soluble phosphorus content of the soil	105.10		105.10	

0.957 kg/ha P, while in the phytomass of mosses and lichens 0.506 kg/ha, in the subterranean phytomass 5.613 kg/ha, and the amount of available phosphorus in the soil is 31.7 kg/ha. Since the material of the root fraction is dominant in the phytomass, 70% of the phosphorus incorporated in the phytomass is found in the roots. Among the aboveground parts, of the quantity of the phosphorus is most considerable in the dead floral parts, where it is about 15% of the total plant phosphorus. The "other flowering" fraction owing to its small volume of phytomass contains the smallest quantity of phosphorus, whereas its phosphorus concentration — as has been seen — was the highest.

The quantity of phosphorus that can be incorporated in the soil of monoliths — in spite of its low concentration — is about four times the phosphorus quantity of the phytomass. Considering that the quantity of phosphorus which can be incorporated is only some 2—3% of the total phosphorus content of the soil (FEKETE—HARGITAI—ZSOLDOS, 1967), we can see that the substrate has a considerable pool of phosphorus.

The dynamics of nitrogen

The total N-concentration of the phytomass fractions and of the soil of the monoliths is shown in Table 3. Similarly as in the case of phosphorus, the nitrogen concentration is also the highest in the aboveground plant parts, especially in the living parts of dicotyledons constituting the "other flowering fraction".

The N-concentration of the aboveground dead phytomass is lower than that in the living parts, but the difference is not so great as has been in the case of phosphorus. Among the phytomass fractions of flowering plants, according to our measurements, the nitrogen concentration of the belowground parts is the lowest, however, the difference is only some 10—20%, in comparison with the living parts of *Festuca*.

the plant material and in the soil fractions, Festucetum vaginatae danubiale 1971

VI.		VII.		VIII.		IX.		X.	
mg	%	mg	%	mg	%	mg	%	mg	%
0.93	3.17	0.85	2.76	0.78	2.20	0.95	3.95	0.89	3.50
0.13	0.44	0.23	0.75	0.39	1.10	0.38	1.58	0.33	1.30
3.84	13.06	5.25	17.05	5.24	14.80	4.03	16.78	5.03	19.78
2.03	6.89	2.62	8.51	2.15	6.08	2.93	12.18	2.16	8.48
22.45	76.44	21.83	70.93	26.84	75.82	15.74	65.51	17.03	66.94
29.37	100.00	30.78	100.00	35.40	100.00	24.03	100.00	25.44	100.00
126.8		126.8		115.9		105.1		184.8	

Table 3

Total nitrogen concentration of the phytomass fractions in Festucetum vaginatae danubiale grassland, mg %

1971	IV.	V.	VI.	VII.	VIII.	IX.	X.
Aboveground living material of *Festuca vaginata*	1392.54	1066.00	884.00	954.17	1218.00	1454.63	1334.32
Aboveground living "other flowering" parts	1923.81	1898.12	1206.89	1345.81	1803.72	1980.63	2061.08
Aboveground dead flowering phytomass	1000.00	912.67	874.66	941.33	999.33	1008.00	930.00
Moss-lichen phytomass	933.33	794.66	939.33	981.33	1046.67	1056.66	1006.66
Belowground phytomass	1066.66	903.33	846.66	856.66	866.66	926.66	923.33
Total nitrogen concentration of the soil	40.64	30.93	40.46	29.47	33.06	34.84	41.97

In our sampling area the N-content of the moss-lichen fraction is lower than that in the flowering plants, only in autumn it reaches 1000 mg% that is an about 1% value. Similar results were obtained when examining the N-metabolism of lichens in more details (VERSEGHY—KOVÁCS-LÁNG 1974).

The fluctuations in the N-concentration of the individual phytomass fractions are different during the vegetation period. The fluctuations in the N-content is of the smallest value — about 10% — in the aboveground dead phytomass fraction, while it is highest in the aboveground living parts of *Festuca vaginata*, where it amounts to about 35%. It is interesting that the nitrogen concentration of the "other flowering" fraction of heterogeneous species composition does not show a fluctuation of too high value, it is only about 25%.

In the aboveground flowering parts it is characteristic of the course of seasonal changes in the N-content that after showing high values early in

Table 4

The quantity of nitrogen accumulated in the plant material and in the soil of monolith (mg/monolith)

	IV.		V.	
	mg	%	mg	%
Aboveground living material of *Festuca vaginata*	7.41	1.29	11.30	2.47
Aboveground living "other flowering" parts	1.78	0.31	3.53	0.77
Aboveground dead flowering phytomass	70.76	12.35	68.08	14.88
Moss-lichen phytomass	45.26	7.90	41.00	8.96
Belowground phytomass	447.86	78.15	333.50	72.91
Total plant nitrogen	573.07	100.00	457.41	100.00
The total nitrogen content of the soil	4908.31		3736.34	

springtime, it gradually decreases until July, then in September and October reaches again a maximum which overpasses the spring values. According to the measurements of FARTUSHINA (1971), the N-concentration of the aboveground plant parts is the highest in springtime, then it gradually decreases and shows a minimum in October. The autumn second maximum measured by us in the *Festucetum vaginatae* steppe meadow may be related to the differing developmental rhythm of this steppe meadow. Our informative N-content measurements, carried on from the dry matter of our phytomass examinations of 1968, also showed a September maximum, similar to the measurements in 1971.

The N-content of the belowground parts shows a pattern similar to that in the aboveground living fraction. The higher N-content of the litter in April and September may be in relation with the increase in the biomass of the micro-organism decomposing the litter in these periods, which was indicated also by BASILEVICH (1965).

The total N-concentration of the soil of monoliths is a very low value. This is in correlation with the low organic matter content of the weakly humic sandy soils. 99% of the nitrogen in the soil is in organic binding with the humic matters of the soil and it is only a very small proportion some 1%, that can be mobilized easily. The total nitrogen content of the soil shows sharp fluctuations at the beginning of the vegetation period. Its value is low in summer, but rises by autumn.

The N-quantity that can be found in the phytomass and in the soil, calculated for a unit area and a corresponding soil layer is shown in Table 4. The quantity of incorporated N is determined by the phytomass, similarly to phosphorus. The quantity of N present in the phytomass fractions and in the upper 20 cm layer of the soil, calculated for one hectare, for example in June, is as follows: in the aboveground living matter of *Festuca vaginata* it is 2.452 kg/ha, in the aboveground living matter of other flowering plants it is 0.397 kg/ha; in the aboveground dead flowering phytomass it is 15.722 kg/ha; in

and its distribution in the phytomass fractions Festucetum vaginatae danubiale 1971

VI.		VII.		VIII.		IX.		X.	
mg	%	mg	%	mg	%	mg	%	mg	%
9.81	2.34	9.64	2.21	10.35	2.21	12.42	3.18	11.61	2.95
1.59	0.38	2.42	0.55	4.69	1.00	8.52	2.18	4.53	1.15
62.89	14.99	88.95	20.38	84.54	18.07	74.79	19.13	84.07	21.34
31.88	7.60	41.71	9.56	35.37	7.56	56.21	14.37	34.53	8.77
313.38	74.69	293.75	67.30	332.94	71.16	239.08	61.14	259.18	65.79
419.55	100.00	436.47	100.00	467.02	100.00	391.02	100.00	393.92	100.00
4887.57		3559.97		3993.65		4208.67		5069.97	

moss-lichen phytomass 7.970 kg/ha, in the belowground phytomass it is 78.345 kg/ha; and the total N-content of the corresponding soil layer is 1221.890 kg/ha.

The greatest portion (60—70%) of the N incorporated in the plant parts of monoliths is found in the roots, since this is the most significant one among the phytomass fractions. Among the aboveground plant parts, the dead flowering fraction contains 15—20% of the total plant nitrogen, the cryptogamous fraction contains 8—9% while the living flowering parts only some 2—4% of the total plant nitrogen.

The seasonal changes in the nitrogen quantity accumulated in the individual phytomass fractions correspond to the seasonal changes in phytomass fractions.

The quantity of total N-content present in the soil of the monoliths is almost ten times that of the plant nitrogen. The distribution of the N-content of monoliths between soil and plant components is shown in Table 7.

The dynamics of potassium

The potassium concentration of the phytomass fractions and the total and the soluble potassium concentration of the soil are shown in Table 5. The potassium concentration is the highest in the aboveground "other flowering"

Table 5

Total potassium concentration of the phytomass fractions in Festucetum vaginatae danubiale grassland, mg %

1971	IV.	V.	VI.	VII.	VIII.	IX.	X.
Aboveground living material of *Festuca vaginata*	744.91	987.33	663.33	587.16	656.66	671.11	696.29
Aboveground living "other flowering" parts	1328.01	1126.19	844.83	908.73	1177.06	948.19	1253.62
Aboveground dead flowering phytomass	175.33	190.13	160.00	166.66	182.66	164.00	177.33
Moss-lichen phytomass	220.00	220.66	200.66	205.33	225.33	222.80	256.00
Belowground phytomass	230.33	256.33	256.00	225.00	237.40	186.66	187.33
Total potassium concentration of the soil	107.30	109.90	106.90	105.30	101.30	96.70	98.60
0.1 n acid-soluble potassium concentration	4.85	4.83	4.96	4.76	4.90	4.40	4.42
Potassium concentration soluble in ammonium lactate	4.56	4.18	4.56	4.15	4.15	3.73	5.56
Water-soluble potassium concentration	1.24	1.12	1.26	0.95	1.06	1.03	1.19

living phytomass fraction consisting mainly of dicotyledons. The K-content of the aboveground living parts of *Festuca vaginata* is much lower than this.

Especially high is the difference in the potassium concentration of the living and dead parts of the aboveground flowering phytomass. Since the dead parts originate mainly from the *Festuca vaginata*, the K-content of the dead parts is compared with the living parts of the dominant constituents of grassland. Taking this as a basis, it can be inferred that the percentage K-content of the dead parts is only about a quarter of that of the living parts. A possible reason for this is the great mobility of K, and its basipetal distribution within the plants. A large proportion of K is concentrated in the growing young parts, the aging decaying parts are from the beginning of low K-content. After the decay in plant parts, the K from them can be easily washed out. All these factors together can explain the very low K-content of the litter.

The potassium content of the belowground parts is also much lower than that of the aboveground living parts, but it surpasses that of the aboveground dead parts.

The potassium concentration of the cryptogamous fraction is also characterized by low values and low fluctuation.

The fluctuation of the K-concentration during the vegetation period is of different extent in the phytomass fractions. The aboveground dead flowering fraction showed the lowest fluctuation (about 15%), but the fluctuation found in the cryptogams is near to that (about 15%). Fluctuation is strong in the living aboveground parts of flowering plants, where it amounts to about 40% in the case of both the dominant species of grassland and the "other flowering" plant parts.

The total K-concentration that can be found in the soil is much lower than that in the plant matter. At the beginning of the vegetation period, higher values are characteristic of it, but from August on K-concentration shows a definite decrease.

The quantity of K accumulated in the plant matter and soil of monoliths is shown in Table 6. Its quantities calculated for one hectare are, for example, in June as follows: in the aboveground living matter of *Festuca vaginata* 1.84 kg/ha; in the "other living flowering" parts it is 0.28 kg/ha, in the aboveground dead flowering phytomass it is 2.87 kg/ha, in the phytomass of mosses-lichens 1.70 kg/ha; in the belowground phytomass 23.68 kg/ha while the quantity of the total K in the soil is 3228.4 kg/ha; from this, 148.8 kg/ha is acid-soluble, and 38.05 kg/ha is water-soluble.

The K-distribution in the phytomass fractions, similarly as in N and P, corresponds to the proportion of phytomass fractions. The quantity of the total accumulated in the soil surpasses the quantity of plant potassium; the latter does not reach even one per cent that of the former (Table 7).

Table 6

The quantity of potassium accumulated in the plant material and in the soil vaginatae

	IV.		V.	
	mg	%	mg	%
Aboveground living material of *Festuca vaginata*	3.95	3.13	10.46	7.89
Aboveground living "other flowering" parts	2.52	2.00	2.09	1.58
Aboveground dead flowering phytomass	12.41	9.83	14.18	10.68
Moss-lichen phytomass	10.67	8.45	11.38	8.57
Belowground phytomass	96.71	76.60	94.64	71.29
Total plant potassium	126.26	100.00	132.75	100.00
Total potassium content of the soil	12 961.84		13 275.92	
Acid soluble potassium content of the soil	585.88		583.46	
Water-soluble potassium of the soil	149.79		135.29	

Table 7

Distribution of the total nitrogen and potassium content Festucetum vaginatae

	IV.		V.	
	mg	%	mg	%
Total nitrogen content of the monolith	5 482.38	100	4 193.75	100
Plant nitrogen	573.07	10.45	457.41	10.91
Soil nitrogen	4 908.31	89.55	3 736.34	89.09
Total potassium content of the monolith	13 088.10	100	13 408.67	100
Plant potassium	126.26	0.96	132.75	0.99
Soil potassium	12 961.84	99.03	13 275.92	99.00

Discussion and conclusion

Comparing the occurrences and quantities of the elements examined in the various phytomass fractions, we can infer that the concentration of the nitrogen is the highest, potassium is lower than that, while the concentration of phosphorus is almost one order smaller than that of the former two.

All three elements occur in the highest concentration in the aboveground living parts. Their distribution within the phytomass fractions of the flowering plants is not totally uniform. The decrease in the nitrogen concentration shows the order of aboveground living parts, aboveground dead parts, and roots. In the case of potassium and phosphorus: aboveground living parts, roots, aboveground dead parts is the order of concentration decrease in the elements.

In the phytomass of the cryptogams, the concentration of the elements examine — that is $N > K > P$ — shows a similar order. The concentration of all three elements is much lower in the soil.

of monoliths (mg/monolith) and its distribution in the phytomass fractions Festucetum danubiale 1971

VI.		VII.		VIII.		IX.		X.	
mg	%	mg	%	mg	%	mg	%	mg	%
7.36	6.06	5.93	5.43	5.58	4.54	7.11	8.53	6.05	7.02
1.11	0.91	1.63	1.49	3.06	2.49	4.07	4.88	2.75	3.19
11.50	9.46	15.74	14.42	15.45	12.57	12.17	14.60	16.03	18.60
6.81	5.61	8.72	7.99	7.62	6.20	11.85	14.22	8.78	10.19
94.75	77.96	77.15	70.67	91.21	74.20	48.16	57.77	52.58	61.00
121.53	100.00	109.17	100.00	122.92	100.00	83.36	100.00	86.19	100.00
12 913.52		12 720.24		12 237.04		11 681.36		11 910.88	
599.17		575.11		591.92		531.52		533.94	
152.21		114.76		128.05		124.42		143.75	

of monoliths between soil and plant components danubiale 1971

VI.		VII.		VIII.		IX.		X.	
mg	%	mg	%	mg	%	mg	%	mg	%
5 307.12	100	3 996.44	100	4 461.55	100	4 599.69	100	5 463.89	100
419.55	7.91	436.47	10.92	467.90	10.49	391.02	8.50	393.92	7.21
4 887.57	92.09	3 559.97	89.08	3 993.65	89.51	4 208.67	91.50	5 069.97	92.79
13 035.05	100	12 829.41	100	12 359.65	100	11 764.72	100	11 997.07	100
121.53	0.93	109.17	0.85	122.92	0.99	83.36	0.71	86.19	0.72
12 913.52	99.06	12 720.24	99.14	12 237.04	99.00	11 681.36	99.29	11 910.88	99.28

The quantities of elements accumulated in the phytomass and in the soil weight/surface or volume unit show different proportions.

Since the phytomass is identical, the quantity of nitrogen, potassium and phosphorus accumulated in the plant parts, calculated for a unit area, change in the order of the concentration proportions.

On one hectare in the upper 20 cm soil layer of *Festucetum vaginatae* danubiale grassland, the quantity of the nitrogen accumulated in the total phytomass is about 100 kg, that of the potassium is about 30 kg, and that of the phosphorus is about 7—8 kg. At the same time, the total nitrogen content of the corresponding soil layer is about 1200 kg; its potassium content is about 3200 kg, its phosphorus content is 300—500 kg. The quantities that can be incorporated from the latter are: 12 kg nitrogen, about 150 kg potassium and about 30 kg phosphorus.

Examining the distribution of the individual elements in the plant-soil system, the following estimations can be made.

The distribution of the organic matter between the soil and plant parts of monoliths is about 50—50% (KOVÁCS-LÁNG, 1974). This can be accepted as a proportion of the distribution of carbon present in the system.

In the soil-plant system, nitrogen shows a distribution of 90 : 10 proportion; phosphorus 97 : 3; and potassium 99 : 1 proportion. Thus, it can be seen that in this system — which is represented by monolith samples — a changing proportion of the elements is incorporated in the phytomass, i.e a changing proportion is under biological control.

The elements whose reservoir is the soil (P and K) may in their overwhelming majority by found in the soil. The nitrogen, whose main reservoir is the atmosphere, can be found to a rather high proportion in the soil — mainly bound in organic matters which are to a large part dead or humified. The portions of carbon and nitrogen that can be found in the soil indicate that carbon-turnover in this plant-soil system is faster.

The turnover of the elements is most intensive in the aboveground living parts. The changes in the nutrient supply of the roots are of smaller extent. The possible cause of this is that in this fraction the dead and the living parts have been considered together. Quite slow processes are characteristic of the turnover in the nutrient store of the aboveground dead flowering parts. The above mentioned turnover rates were characteristic of the intensity in the dynamics of the elements only in the vegetation period examined.

The quantity relations of the examined elements accumulated in the phytomass in comparison with the movable and absorbable element supply of the soil is different.

The quantity of the potassium present in a unit area of the phytomass is about the same as the watersoluble K-supply of the soil at the same place.

Table 8

The turnover rate of phytomass and the individual elements examined, in %

	Total organic matter of the phytomass (C)	P	N	K
Aboveground living matter of *Festuca vaginata*	52	53	40	62
Aboveground living "other flowering" phytomass	70	66	81	73
Dead aboveground flowering phytomass	25	22	29	28
Belowground phytomass	38	46	46	50
Moss-lichen phytomass	36	31	43	43

However, for the plants, even about four times of this quantity is available from the acid-soluble potassium.

The quantity of the phosphorus present is the phytomass is about a third or a quarter of the absorbable supply present in the soil.

In the case of nitrogen, the case is reversed, since the N-quantity in the phytomass calculated for a unit area is about eight—ten times the quantity of absorbable nitrogen found in the soil, which is only about 1% of the total nitrogen. The distribution indicates that the available nitrogen in the soil can restrict the quantity of N incorporating in the organic matter, and so also the production itself, as a minimum factor.

The nutrient distributions found by us in the examined grassland community entirely correspond to the inferences drawn by agrarian experts, according to which in sandy soils it is mainly the lack of nitrogen which can be felt, the proportion of phosphorus is more favourable, while the lack of potassium is a rather rare phenomenon on the domestic sandy soils (LÁNG, 1973).

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A SURVEY OF STUDIES ON GRASSLAND PRODUCTION IN HUNGARY

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The paper presents a survey of grassland (meadow-pasture) yields investigated by botanists in Hungary. Measurements were made in the confines of 60 different villages. The names of plant communities used by the various authors in their work published before 1975, the results of yield measurement of the 32 communities (values converted into g/m^2) and the name of the authors are given. The highest yield was measured in *Scirpo-Phragmitetum glycerietosum*.

At the beginning of phytocenology as a science, research workers evaluated the vegetation production of a meadow by measuring the weight of vegetation per unit area. Harvested material was grouped according to species and the weight of each species was measured. The dominance of the species was expressed by its share percentage in total weight. These investigations were undertaken with a practical purpose in mind (see e.g. STEBLER and SCHRÖTER). During the later development of phytocenology, researchers abandoned weight measurement in favour of abundance and dominance (A—D) evaluation (BECKING, 1957) which proved to be a more rapid procedure and, for certain purposes, to be more advantageous.

Estimation of the weight of vegetation can be made by direct or indirect methods (LIETH, 1962). To asses the yield of grasslands in Hungary, UBRIZSY (1943), BALÁZS (1949) and BODROGKÖZY (in HARMATI—BODROGKÖZY, 1965) recommend the indirect method. The suggested formulae are based on A—D values and on hight measurements of the vegetation. But reliability of neither formulae has been established.

Up to the 1960's, before the IBP was established, MÁTHÉ, KOVÁCS, JEANPLONG, KOLTAY and PRÉCSÉNYI have applied the harvest and monolith methods to obtain direct yield measurements.

Before the IBP was launched, yield measurements of meadows and pastures were directed by meadow quality analysis and by typology. These measurements, in most cases, were carried out during one year and maybe only on a single occasion.

One of the objectives of the IBP's PT section was to appraise the vegetation yield of the earth and to examine the factors affecting this yield. In order to coordinate research activities, methodological guidelines have been issued.

In Hungary, the Újszentmargita and Csévharaszt nature conservation areas became the experimental field of the IBP. Meadow and pasture plant associations with respect to production have been systematically studied for several years.

The present paper gives a summary of examinations carried out at the grassland associations of Hungary; it is based on reports published up to 1975, but it ignores measurements which were taken on treated (e.g. fertilized, irrigated, etc.) stands, furthermore, it disregards reports which give no clear indication of the yield (e.g. only the percentage of yield share of each species in the total yield but not the quantity of the total crop).

The reports could have been grouped according to several aspects (e.g. provinces, associations or units above associations, researchers). In a certain sense, the introduced grouping follows the historical sequence. Of course, there are researchers whose activities show an almost unbroken continuity. The writer of this paper is of the opinion that the division into two parts will facilitate the survey of material which is further promoted by the fact that an attempt has been made to follow the coenosystematic grouping as given in Table 1 and in Fig. 1, indicating those areas in the country where yield has

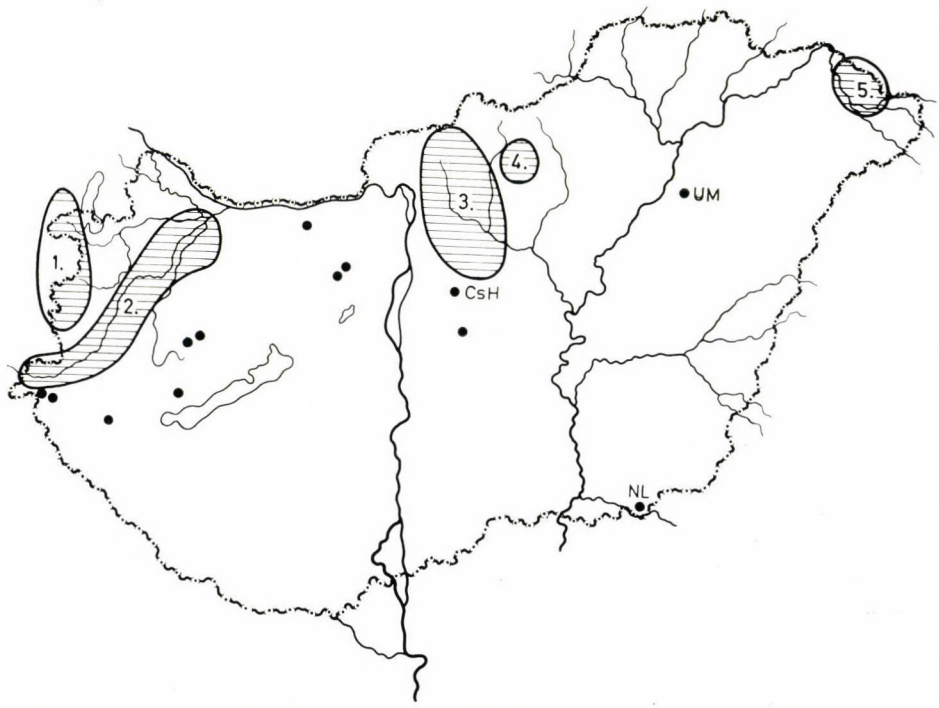

Fig. 1. Grassland areas of Hungary where yield measurements were made. 1. The Sopron-Kőszeg Mountain Range; 2. Flood plain of the Rába River; 3. The Cserhát and the Gödöllő hills; 4. The Mts. Mátra; 5. The Bereg Plain; Dots indicate marshlands; CsH = Csévharaszt; UM = Újszentmargita; NL = Nagylak

Table 1

The production of various grasslands in Hungary

Name of plant association	Production (g/m^2)	Author
1. *Scirpo-Phragmitetum glycerietosum*	810—1060	MÁTHÉ (1968)
2. *Caricetum elatae*	260	MÁTHÉ (1956)
3. *Caricetum gracilis*	275—343	MÁTHÉ (1956)
4. *Caricetum paradoxae*	210	MÁTHÉ (1956)
5. *Caricetum acutiformis-ripariae*	425	MÁTHÉ (1956)
6. *Nardo-Festucetum ovinae alopecuretosum*	200—250	MÁTHÉ—KOVÁCS (1960)
7. *Molinietum coeruleae*	120—250, 154	KOVÁCS (1956), JEANPLONG (1959)
8. *Junceto-Molinietum*	115—210	KOVÁCS (1956)
9. *Deschampsietum caespitosae*	200—250	JEANPLONG (1959)
10. *Agrostetum albae*	210, 155, 375	MÁTHÉ (1956), JEANPLONG (1959), JUHÁSZ-NAGY (1959)
11. *Alopecuretum pratensis*	430, 347	MÁTHÉ (1956), JEANPLONG (1959)
Alopecuretum ranunculetosum acris	430	JUHÁSZ-NAGY (1959)
12. *Festucetum pratensis*	300, 225, 305	MÁTHÉ (1956), JEANPLONG (1959), JUHÁSZ-NAGY (1959)
13. *Phalaridetum* *Rorippo-Phalaridetum*	360 220—260	MÁTHÉ (1956) JEANPLONG (1968)
14. *Arrhenatheretum elatioris*	520—698, 385—435, 522	MÁTHÉ (1956), JEANPLONG (1959, 1970)
15. *Arrhenatheretum-alopecuretosum*	610	MÁTHÉ—KOVÁCS (1960)
16. *Festuco rubrae-Cynosuretum*	150—220	MÁTHÉ—KOVÁCS (1960)
17. *Festuco rubrae-Cynosuretum arrhenatheretosum*	300—400	MÁTHÉ—KOVÁCS (1960)
18. *Cynodonteto-Lolietum*	140—174	MÁTHÉ (1956)
19. *Antoxantheto-Festucetum pseudovinae*	490	JUHÁSZ-NAGY (1959)
20. *Agrostis alba-Beckmannia eruciformis*	530—630	MÁTHÉ (1968)
21. *Achilleo-Festucetum pseudovinae*	300—450	MÁTHÉ—PRÉCSÉNYI (1970, 1973)
22. *Artemisio-Festucetum pseudovinae*	280—325	PRÉCSÉNYI (1969)
23. *Peucedano-Galatelletum punctati*	230—480	ZÓLYOMI—PRÉCSÉNYI (1970)
24. *Brometum tectorum*	125—230, 207, 240—420	MÁTHÉ—KOLTAY—PRÉCSÉNYI (1954), MÁTHÉ (1956), VERSEGHY—K. LÁNG (1971)
25. *Festucetum vaginatae*	310—400	VERSEGHY—K. LÁNG (1971)

Table 1 (cont.)

Name of plant association	Production (g/m^2)	Author
26. *Festucetum wagneri*	280—450	VERSEGHY—K. LÁNG (1971)
27. *Mesobrometum*	160—215	MÁTHÉ—KOLTAY—PRÉCSÉNYI (1954)
28. *Potentillo-Festucetum pseudovinae*	230	MÁTHÉ (1956)
29. *Festucetum pseudovinae*	200—220, 150	MÁTHÉ—JEANPLONG (1954), JUHÁSZ-NAGY (1959)
30. *Chrysopogonetum grylli*	150—200	MÁTHÉ—JEANPLONG (1954)
31. *Festucetum sulcatae*	140—170, 120—150	MÁTHÉ (1956), MÁTHÉ—KOLTAY—PRÉCSÉNYI (1954)
32. *Cynodontetum*	85—220, 150	MÁTHÉ—KOLTAY—PRÉCSÉNYI (1954)

been measured although the individual areas are not marked (a total of about 60 localities). The reported yield values have been converted into g/m^2 and are given in Table 1. where not only yield data are indicated but also the names assigned to the associations by the author, the author, and the year of publication (ELLENBERG's work, published in 1952, informes the reader on the names of plant associations). In Fig. 2. the numbers under the column indicate the serial numbers listed in Table 1. If an author gave more than one data for the same association, minimum and maximum values are given here.

Yield measurements and investigations in meadow typology

MÁTHÉ (1956) deals with the various types of meadows and pastures of the Cserhát and the Gödöllő hills. He surveys the yield of some 15 hygrophilous, mezophilous and xerophilous plant communities, establishes the quality of hay, and its ash and raw protein content. The largest quantity and the highest quality of hay grows on *Arrhenatheretum* meadow. The production of the hygrophilous-type meadow is not less than that of the mezophilous or the xerophilous-type meadows, although their feeding value is low owing to the high ratio of the various species of sedge. The quantity as well as the quality of yield diminishes toward the end of the summer.

In Babatpuszta, near Gödöllő, where deforestation resulted in degradation, ecological and production investigations on the evolved meadow were conducted by MÁTHÉ and JEANPLONG (1954). They reported the weights of the

above- and underground plant parts and the phenologic relations of plant associations. Results of monolith examinations indicate that the aboveground part of the vegetation represents only a small percentage of the underground part; however, the ratio changes during the vegetation period. The disturbance of vegetation causes extensive decrease in the yield of both parts. Two-thirds of the underground parts is found in a depth of 0 to 10 cm.

MÁTHÉ, KOLTAY and PRÉCSÉNYI (1954) have examined the changes in underground plant parts effected by the depth and the phenological aspects of plant associations on six pastures of Szárítópuszta near Gödöllő. Of all stands, *Festucetum sulcatae* has the largest grass yield with respect to both the above- and the underground parts. The lowest yield was measured in *Brometum tectorum* containing numerous annuals. Generally 70% of the root mass was found in a depth between 0 and 10 cm. Root density within the same period changed per phytocenosis and the change of the latter was related to the various phenophases.

KOVÁCS (1964) reports on the weight of underground plant parts and on the seasonal rythm of production on marshlands and hayfields near Galga. The weight of underground plant parts reached a maximum in the spring and autumn, and had a minimum level in the summer. The moisture content of the soil effects the root weight; plant associations supported by soil richer in moisture reached their maximum root weight in May, while the root weight of plant associations in drier soils had their maximum in September. During the growth of the aboveground parts, the root weight might decrease by 10 to 15%.

MÁTHÉ and KOVÁCS (1960) carried out meadow typological studies in the Mts Mátra with respect to possible economic utilization. They distinguished 5 meadow types and within subtypes several facies, some of good quality and of high hay yield *(Festuco rubrae—Cynosuretum arrhenatheretosum, Arrhenatheretum elatioris alopecuretosum)*. After deforestation, the production of *Festuceto rubrae—Cynosuretum*, evolving as the first community was half or one-third of that of the preceding one (Fig. 2).

A coenological and ecological survey of the communities *Molinietum coeruleae* and *Junceto-Molinietum*, covering relatively large areas in Hungary, was made by KOVÁCS (1956). Based on samples collected from 20 different locations in the country, the quantity of phytomass was determined as being less at the time of the first harvest (May, June) than in the period of the second one (August, September) when the phytomass is nearly twofold. This can be explained by the ontogenetical development of the cespitose species. The yield of transitional stands towards pastures is higher than of the *Molinietum* meadows. The difference in yield between the calcareous and the siliceous pastures is a minimal one (Table 1). The weight of underground plant parts was obtained by the author from $20 \times 20 \times 40$ cm monolith sample data.

Kovács reports that 70 to 80% of the root weight is found in a depth of 0 to 10 cm. Root weight distribution at various depth levels is similar to that of other meadow and pasture communities. At the depth level studied, the weight of underground plant parts exceeds only slightly the weight of the aboveground parts.

Data on the yield of an *Arrhenatheretum elatioris* community, comprised of excellent quality grass types as regards grass utilization as feed, in the Sopron and Kőszeg Mountains was made available by Jeanplong (1970). Yield agrees with the *Arrhenatheretum* harvest crop of other regions already

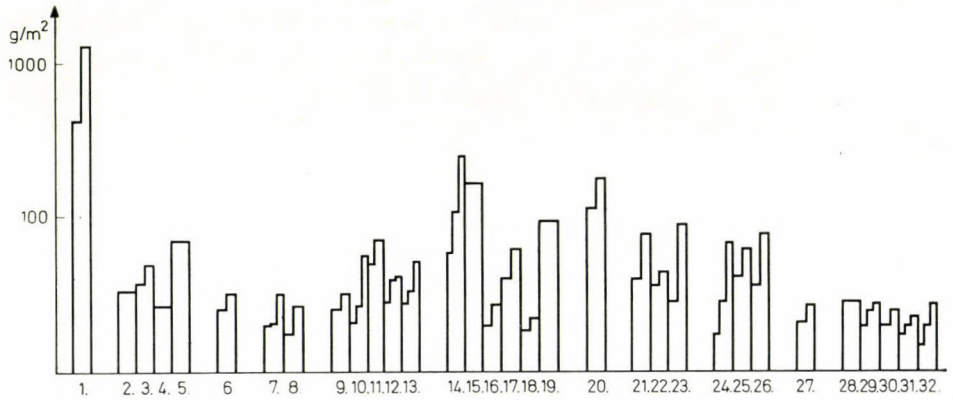

Fig. 2. Yield of the studied communities in g/m²

described (Máthé, 1956). Jeanplong investigated the meadow types of the Rába flood plain with a similar purpose. The meadows of the flood plain are of secondary character, with pronounced anthropogenous effects. This is well reflected by the decreased yield of the *Arrhenatheretum elatioris* meadow type if data on yield are compared with those supplied by Máthé (1956) and Jeanplong (1970). Harvesting on the meadows of the flood plain occured in June and August: the first harvest yielded more phytomass than the second one, similarly to those of the *Rorippo-Phalaridetum* stands in this area, in which a decreased fodder value by the end of summer could also be established (Jeanplong, 1968).

Juhász-Nagy (1959), surveying coenologically and ecologically the meadow and pasture communities of the Bereg Plain estimated hay yield with Balázs's method. This method of estimation considers cover percentage and average grass height. The author calls attention to the fact that when studying the yield of various meadow types, it is necessary to consider the subassociation units, because the facies can produce different phytomass during identical periods.

BODROGKÖZY and HORVÁTH (1969, 1971) studied the production of meadows on alkali soil in the Szeged region. The production was estimated by the aid of the PROM formula, suggested by BODROGKÖZY (see HARMATI and BODROGKÖZY, 1965). Results unfortunately could not be utilized, for reasons mentioned in the introduction.

Examinations of grasslands within the framework of the IBP

The production of the main plant associations in the experimental area of the IBP at Újszentmargita was studied by the members of the Botanical Research Institute of the Hungarian Academy of Sciences. Results of the studies are presented in papers by ZÓLYOMI, MÁTHÉ, PRÉCSÉNYI and SZŐCS (1972, 1974).

Several papers deal with the production of two alkaline associations *Artemisio-Festucetum pseudovinae* and *Peucedano-Galatelletum punctati* found in the experimental steppe meadow area (MÁTHÉ, PRÉCSÉNYI and ZÓLYOMI 1967, PRÉCSÉNYI, 1969a; ZÓLYOMI and PRÉCSÉNYI, 1970). The aboveground plant parts of the *Peucedanetum* forest steppe meadow are more productive than those of the *Artemisietum*. Based on measurement data of several years, it was found that the underground parts of *Artemisietum* exhibit some weight loss wheras the same parts of *Peucedanetum* showed an increase in weight (1967 —69).

Turnover time of the aboveground parts was of the shortest duration in the case of *Peucedanetum*, as compared to other associations investigated, and the turnover of underground parts was also quicker than in those growing on alkali meadows (PRÉCSÉNYI, 1971b).

Alkali meadows support a less efficient association than forest steppe meadows. The calculated efficiency of *Artemisietum* derived from net productivity and from PAR, is between 0.14 and 0.42%, while the efficiency of the forest steppe meadow *(Peucedanetum)* lies between 0.08 and 0.66%. PRÉCSÉNYI analysed the productivity of two associations by considering some other characteristics (efficiency, turnover, diversity) as well as their interrelationships (1969a, 1973). He found that the forest steppe meadow represents a much less stable plant community against varying environmental conditions than the alkali meadow.

Variability in production of the forest steppe meadow is primarily influenced by total radiation and relative humidity. In the case of *Artemisietum*, the influence of mean temperature, and of other factors not considered in the analysis is considerable (PRÉCSÉNYI, 1971a). PRÉCSÉNYI (1970) also investigated the relations of energy distribution of *Artemisietum*. In the community, roots contribute the largest portion of the total production. PRÉCSÉNYI infers

that in the initial state of succession a significant part of the net production is transferred to litter and in a later stage to the roots. The greatest energy loss derives from litter. The production of *Achilleo-Festucetum pseudovinae* (alkali pasture, extending over a large field), has also been investigated. It was possible to compare grazed and nongrazed areas. One of the dominant plants, *Festuca pseudovina*, gave 60 to 80% of the total annual production. *Achillea* gave less (MÁTHÉ and PRÉCSÉNYI, 1970, 1973). While the phytomass of mosses of the nongrazed area was insignificant, it frequently exceeded the weight of *Festuca* on pasture. The production of the grased area was less, and changes in weather have affected the grazed fields to a greater extent than the nongrazed ones. The phytomass of the underground parts was considerably larger during the entire vegetation period than that of the aboveground parts, their ratio exceeding one (MÁTHÉ, PRÉCSÉNYI and ZÓLYOMI, 1967; PRÉCSÉNYI, 1969b). The productivity of the aboveground parts on the nongrazed land is positive while always negative on the grazed area. Turnover occurred in the shortest period on grazed land. Efficiency of the nongrazed area is between 0.7 and 1.9%. The productivity of the nongrazed area was hardly effected by the monthly mean temperature, the monthly total precipitation, relative humidity and total radiation, while factors not considered in the analysis exerted extensive influence (MÁTHÉ and PRÉCSÉNYI, 1973).

MÁTHÉ measured the weight and caloric production of the associations *Scirpo-Phragmitetum glycerietosum* and *Agrostis alba-Beckmannia eruciformis*, and the ratio between the under- and aboveground parts. The production of the *Glyceria* stand is very high (Fig. 2), the most productive among all associations investigated in Hungary. By the end of the vegetation period, the production of both associations increased and the measured caloric values well demonstrate this fact. Increased production is understandable in the light of phenological knowledge of the association.

Contiguous phenological observations, with regard to climatic factors, were made by MÁTHÉ (1967, 1968) and MÁTHÉ, NAGY and SZŐCS (1974). The observations were extended to the phenophase of the species in order to establish the phenological spectrum. The phytomass of a species or of a plant community is influenced by the particular phenophase. The phenophases of species also influence sample variability (PRÉCSÉNYI, 1969a).

Members of the Dept. of Plant Taxonomy and Ecology, University of Sciences, Budapest carried out similar researches in the Csévharaszt experimental area (SIMON, 1971; SIMON and K. LÁNG, 1972). They undertook detailed studies of the associations *Brometum tectorum*, *Festucetum vaginatae* and *F. wagneri*. Aboveground parts of perennial plant growing on sand gave two production maxima (June and September). The production maximum of the underground parts preceded that of the aboveground parts (April, May), and their quantity exceeded that of the aboveground parts during the vegetation period. The

annual productivity mean of *Brometum tectorum* was negative, of the other two meadow communities positive, as observed during the sampling period. The weight of the total aboveground phytomass was represented to a considerable extent by the phytomass of moss and lichen synusia: in *Festucetum vaginatae* they occur in greater masses than the flowering plants. The quantity of lichens decreases with the progressive closing of the grass cover. In all three associations the phytomass of lichens is at a minimum during the summer, and this minimum derives from the decrease of their physiological activity (VERSEGHY and K. LÁNG, 1971).

It was found that the turnover time increases with the progressive closing of grass cover, and consequently the plant associations become more stable.

The efficiency of associations varies per season, in the fall it reaches maximum: *Festucetum vaginatae* 1.2%, *F. wagneri* 0.35%. The synusia of mosses and lichens are also the most efficient in the fall, efficiency being between 0.75 and 1.43%.

Data on the chlorophyll content, leaf area and the interrelationships between the two have been supplied by SIMON and ORBÁN (1972), and ORBÁN (1972). A close relationship was demonstrated between the measured moisture of the soil in the different depths (between 20—140 cm, and/or 200 cm) and the productivity (K. LÁNG and SZABÓ, 1971). In *Festucetum vaginatae* this relation was established unambiguously. By the closing of the grass cover of meadows the shading effect of plants changes the water household of the soil. On the variability of productivity of perennial grasses, identical weather factors (relative atmospheric humidity and total radiation) exert the greatest effect. In loosely cespitose grasslands other factors play a more significant role (K. LÁNG and SZABÓ, 1973).

An adequate sampling is necessary for a reliable estimation of plant weight (above- and underground parts) and to reduce errors to a minimum (PRÉCSÉNYI, 1967). Investigations in this regard were published only with respect to the alkali *Artemisietum* at Újszentmargita (PRÉCSÉNYI and MÁTHÉ, 1969).

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SCANNING ELECTRON MICROSCOPY OF THE ROOT SURFACE OF WHEAT AND CORN

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By means of scanning electron microscopy the surface of the root of wheat and corn was studied.

Unevenness of the root surface was revealed. An increase in density of the structural elements in a basipetal direction was observed on the surface of root hairs as well as on that of the root itself. The root is covered by a mucilaginous cell wall. In addition, the mucilage is deposited in the form of locally accumulated granules which occur in the highest amount in the vicinity of the root cap and in the root hair zone. The layer of mucilage is not continuous. Some breaks can be observed and, particularly in the zone of cell elongation and differentiation, in the dense, amorphous matrix fibrillar structures appear. During the development of root hairs from the trichoblasts of the wheat root, the outer cell wall is ruptured. It may be supposed that at the same time the mucilaginous layer, the cuticle and the adjoining amorphous matrix is also ruptured. In corn a similar phenomenon was not observed.

The surface of the root hair is also uneven. The tip of the root hair is covered with a mucilaginous "cap". The surface of the basal region of the root hair appears to have a denser structure which is similar to that of the surface of the cells of the zones of elongation and differentiation. The results confirm the perspectives of the application of scanning electron microscopy in biology.

Introduction

The primary contact of the root system with the surrounding medium takes place via the epidermal cells (or rhizodermis) of the root. Most research workers have come to the conclusion that the rhizodermis has a special role in the uptake of water and supply of mineral salts [1, 20, 22]. The main zones detected in the primary structure of the root, i.e. meristematic cells, elongation zone, zone of differentiation or zone of root hairs, respectively, play different roles in the uptake processes. The capacity of the cells of the rhizodermis to take up various substances from the environment increases with their growth and differentiation [18].

The role of the cell wall in ion uptake is determined by its adsorptive capacity. Adsorption is the primary mechanism leading to the concentration of various substances. The cell wall is a characteristic ion-exchange "reservoir" of the cell [19], and this is especially true for the outer walls of the epidermal cells. According to the literature, the outer wall of the cells of the rhizodermis and the wall of the basal parts of the root hairs consist of an inner fibrillar and

of an outer amorphous layer [2, 4, 8]. The matrix of the outer amorphous layer contains pectin, hemicellulose, proteins and randomly oriented cellulose microfibrils. The inner fibrillar layer contains cellulose microfibrils oriented parallel to the longitudinal axis of the cell, "embedded" in lignin, pectic and some other unknown substances. The outer amorphous layer is a continuous one along the whole length of the root hair wall but the inner, fibrillar layer starts only at a certain distance from the semi-spherical root hair tip [4]. In higher plants the external surface of the amorphous layer of the rhizodermis is covered by a mucilaginous layer and a thin film of cuticle [8, 21].

The structure of the outer cell wall and that of their external surfaces have certainly a great importance in the initial phase of uptake processes. Therefore, studies on the structural changes of the external surface of the wall in the course of growth and differentiation of the epidermal cells of the root are of great interest.

In the present paper results of studies on the structure of the external wall surfaces in wheat and corn roots, carried out by the aid of scanning electron microscopy, will be described.

Materials and methods

Roots of two to three-day old seedlings of wheat *(Triticum vulgare* Host., cv. *Krasnozernaya)* and corn *(Zea Mays* L. cv. *Odesskaya* 10), respectively, were used in the experiments. Seeds of both species were germinated in the dark at 25—27°C on moist filter paper in Petri dishes.

The plant material for the examination was prepared by a modified freeze-drying technique [5, 14]. When the roots reached a length of 10—15 mm and the root hairs started to develop the unfixed plant material was frozen in dry ice and transferred into special freeze-drying vessels. Low temperature in the outer reservoir of the vessels was secured by supplying a mixture of dry ice and aceton. Freeze drying was continued for 2.5 to 3 hours. The samples obtained were coated with a thin film of gold in a Hitachi HUS-4 vacuum evaporator. The thickness of the films was 300—400 Å. The samples were then examined in a Hitachi HSM-2A scanning electron microscope at 25 kV.

Results and discussion

Scanning electron microscopy has been used to study the surface of root as well as leaf epidermis [12], the process of deposition of SiO_2 in the outermost cells of the stem of cereals [3, 15], the mechanism of infection of root cells by root nodule bacteria [7]. Cell surfaces in the interior of plant organs have also been investigated by the use of scanning electron microscopy, e.g. the microstructure of conducting vessels, tracheids, fibers and other specialized cell types [16]. In addition, the dispersal of herbicides has also been studied in the scanning electron microscope by using cathodoluminescence as a detection method [17].

The method has a number of distinct advantages. Thus, fixation of the material to be investigated and the preparation of ultrathin sections are not necessary for studies with the scanning electron microscope. This reduces the chance of artifact formation. The freeze-dried material can be regarded as beeing closer to the living state, as to its structure, than the fixed one. Freeze-drying is a rapid process and the chemical composition of the tissue remains essentially unaltered during freeze-drying. This is also true for the fine structure of the cells, except for some smaller changes due to the formation of ice crystals.

A method has been offered by FALK, CUTTER and GIFFORD [9] to examine unfixed plant material without any pretreatment. They have investigated the effect of various fixation methods on the plant material to be studied by scanning electron microscopy [10]. It has been found that the best results can be obtained by studying unfixed material, since this gives results which reflect more truly the natural conditions. In addition, scanning electron microscopy (in contrast to transmission electron microscopy, phase contrast microscopy and microscopy in the dark field) makes it possible to investigate the outer surface of the objects as well.

Scanning electron microscopy opens wide perspectives in the investigation of root epidermal cells as to the changes occuring on their external surface in relation to the uptake of water and mineral nutrients. In spite of the obvious advantage of the method, the literature is very limited in this field.

A paper by DART [7] is devoted to this problem. However, in this work prefixation and infiltration of the plant material with metacrylat has been applied. Polymerization of the metacrylat certainly leads to lateration in the root surface, a problem stressed by the author himself. But even this technique allowed the detection of unevenness on the root surface.

In the present paper results of studies on the surface of wheat and corn roots, carried out on freeze-dried, unfixed material coated with a thin film of gold is described.

A general observation of the external surface of the rhizodermis shows a considerable increase in density of its constituent elements towards the base of the root, from the meristematic zone to the zone of elongation and from that to the zone of root hair formation.

It may be seen in the electron micrograph of Fig. 1 that the surface of the root cap is uneven. There is an extensive network of wrinkles between the longitudinal cell arrays. The surface of the tip of the root cap appears relatively even, but under higher magnification an irregular accumulation of small blocks of amorphous material can be seen (Fig. 2). The released individual cells are dispersed in a disorderly fashion (Fig. 1). The surface of most cells of the root cap in quite smooth with merely some small wrinkles (Fig. 3).

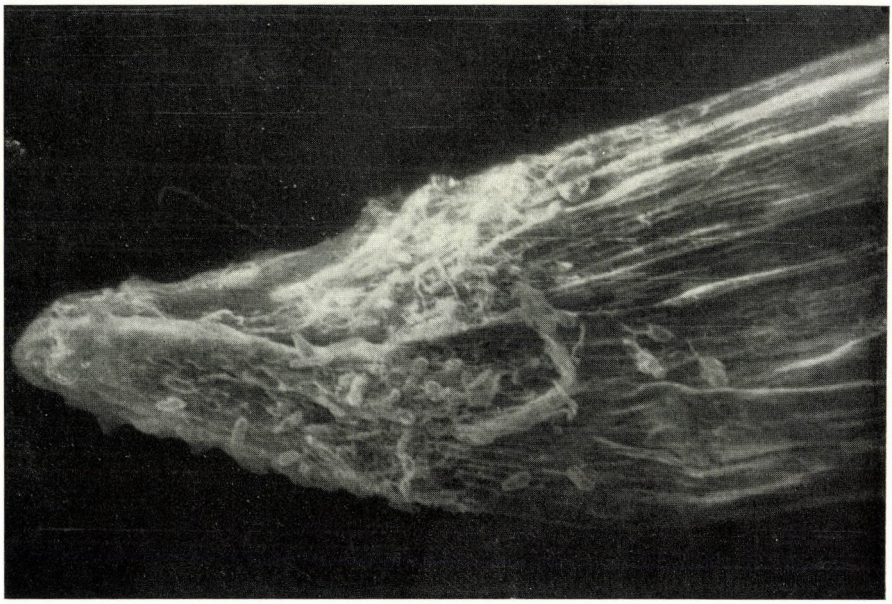

Fig. 1. Root cap. *Zea mays* L. Magnification ×70

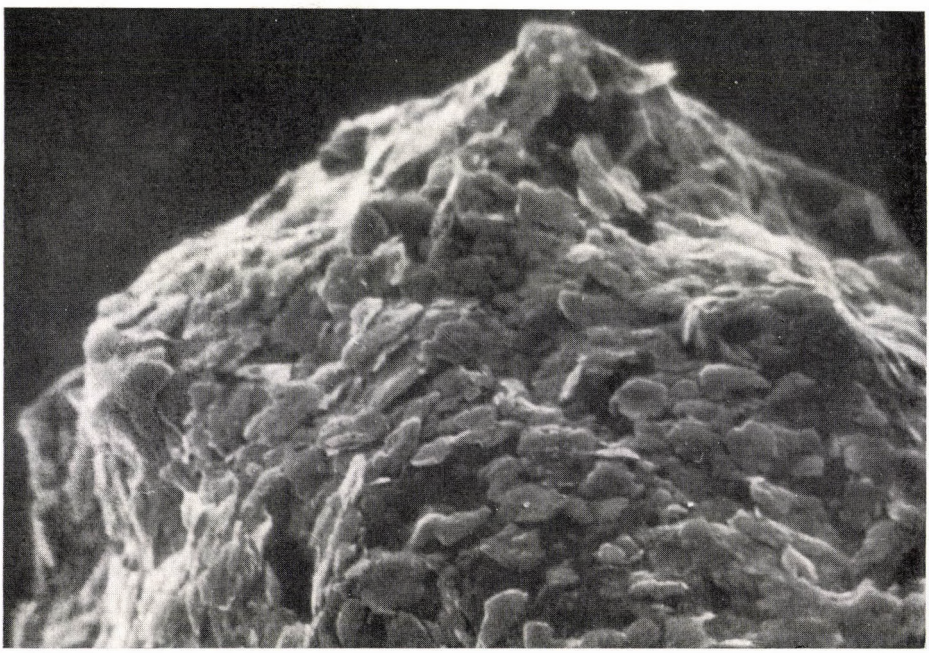

Fig. 2. Surface of the tip of the root cap. *Triticum vulgare* Host. Magnification ×2266

The longitudinal arrays of the cells of rhizodermis are clear-cut all along the wheat and corn roots. The rows become gradually narrower towards the root tip. One can often see the outlines of individual cells (Figs. 7).

In the meristematic zone, both in wheat and corn, a branching network of thin fibrils is to be seen over a smooth surface. Gradually, an amorphous material is deposited in the space between the fibrils (Figs. 4—6).

The electron micrographs probably show different stages of the formation of mucilaginous cell walls. Local accumulation of small globules of mucilage can also be seen. The globules are formed from friable, amorphous material. These are found most frequently in the zone adjoining the root cap. The flat surface, without mucilaginous accumulations, is probably the surface of cuticle.

The presence of mucilage and a thin film of cuticle covering the outer layer of the peripheral root cells and that of the root hairs has been described for a number of higher plants [8, 21]. The cuticle of the root consists of lipids and can be easily stained with dimethylaminobenzene [8]. SCOTT et al. [21] described the thickening of the cuticle film during the growth of the meristematic cells. The cuticle of the root is similar to the cuticle of the overground plant organs in both its chemical nature and its morphology, but the two kinds of cuticles are certainly not identical. At present, even the existence of a cuticle on the surface of rhizodermis is not generally accepted.

The surface of the outer wall of the rhizodermis cells in the elongation zone, both in wheat and corn, is rather flat and smooth. Mucilaginous material accumulates at some places on the cell surface. The root surface is not completely even. The unevenness is due to wrinkles and hollows in the junctions of the longitudinal cell rays. At higher magnification, outlines of longitudinally oriented fibrils are revealed in a dense matrix on the external surface of this root zone (Fig. 8).

In the zone of cell differentiation (zone of root hairs) the surface of the outer epidermal cell walls has a structure similar to that of the cell walls of the cell elongation zone. The surface is flat, dense, and slightly fibrillar. Extensive local accumulation of mucilage can be observed (Figs 9, 11, 12). Thus, on the surface of the cell walls, both in the elongation zone and the zone of differentiation, fibrils may be seen in the dense, amorphous matrix. These fibrils are similar to the cellulose microfibrils of the outer amorphous layer of the cell walls. The presence of two layers, that of an inner fibrillar one with dense, parallel, cellulose microfibrils and that of an amorphous layer with more randomly oriented microfibrils, could be distinguished by means of transmission electron microscopy [4, 8]. These data are in line with the "multi-net" growth pattern of the cell wall as proposed by HOUWINK and ROELOFSEN [13].

A characteristic peculiarity of the zone of cell differentiation is the formation by the rhizodermis cells (trichoblasts) of root hairs. The appearance

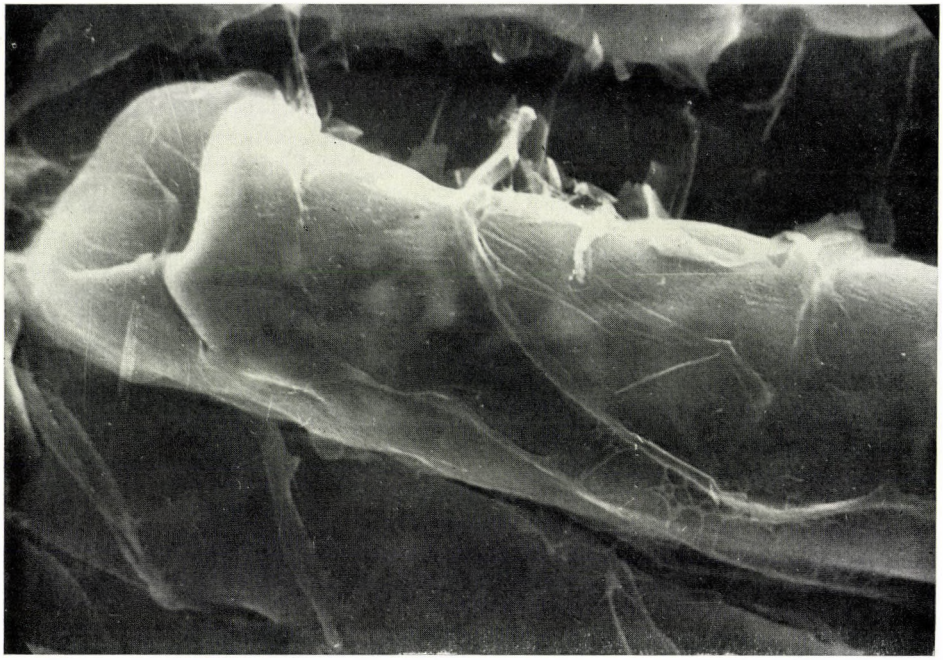

Fig. 3. Structure of the surface of the various cells of the root cap. *Triticum vulgare* Host. Magnification ×2340

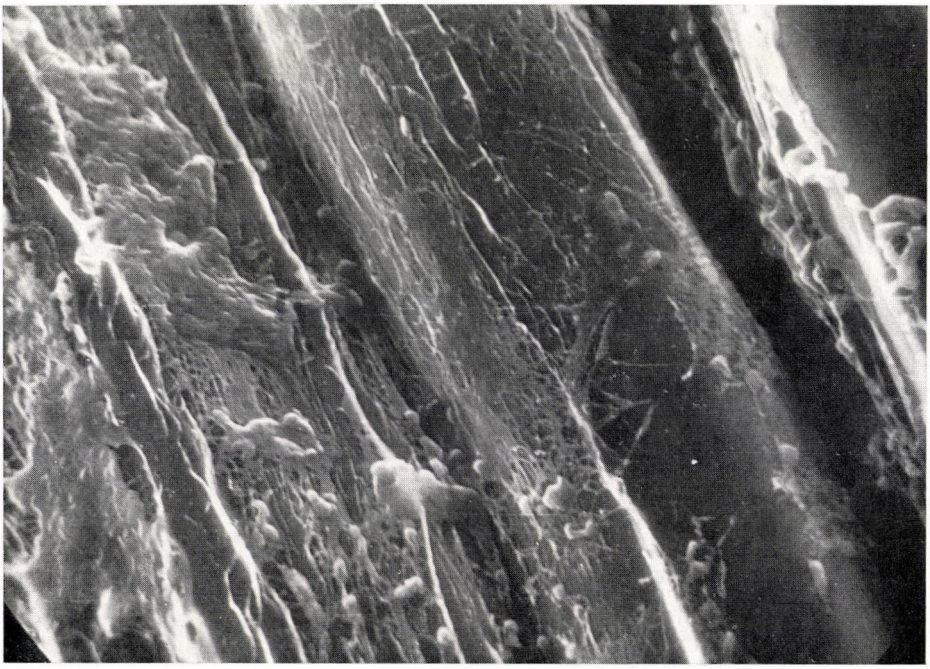

Fig. 4. Surface of the outer cell walls of the meristematic zone. *Triticum vulgare* Host. Magnification ×4220

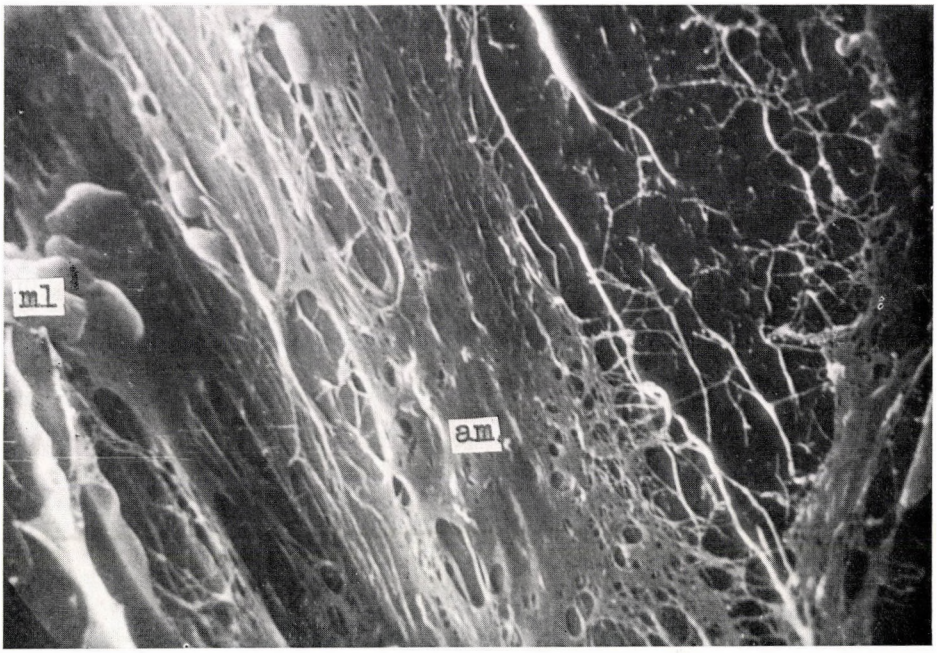

Fig. 5. Surface of the outer cell walls of the meristemic zone. Appearance of amorphous material between the mucilaginous deposits. (am = amorphous material; ml = mucilaginous deposit). *Triticum vulgare* Host. Magnification ×4220

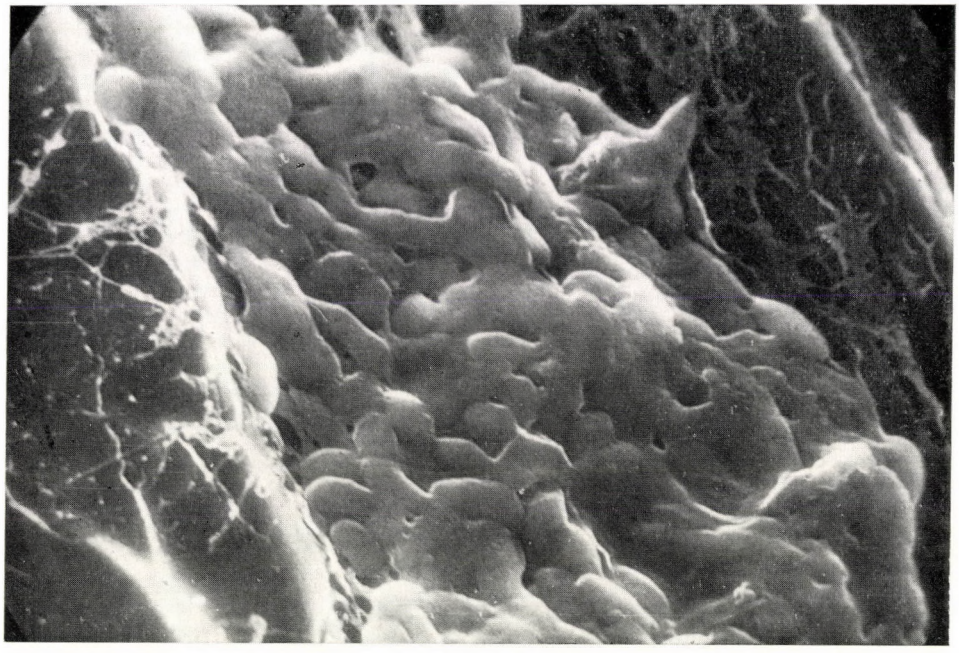

Fig. 6. Structure of the accumulated mucilage on the surface of the root in the meristematic zone. *Triticum vulgare* Host. Magnification ×4220

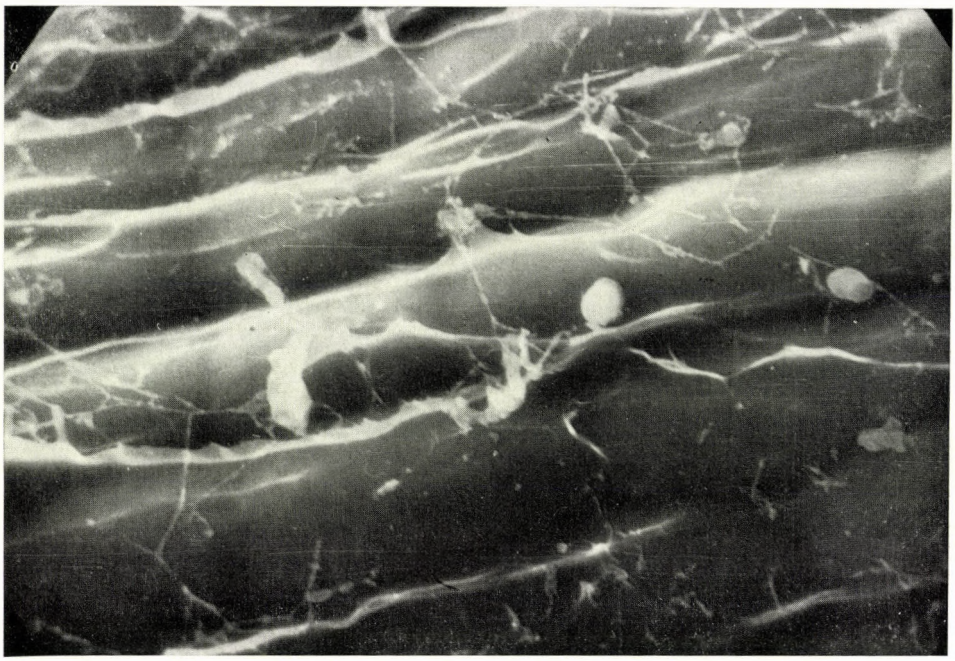

Fig. 7. Surface of the outer cell walls of the meristemic zone of the root. Appearance of the profiles of the individual meristematic cells. *Zea mays* L. Magnification ×2100

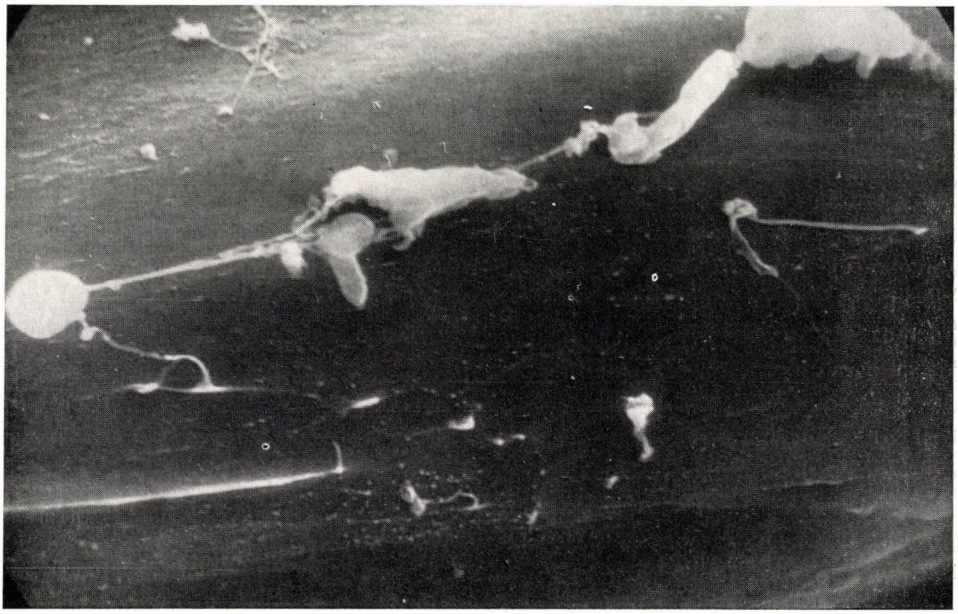

Fig. 8. Surface of the outer cell wall of the external cells of the elongation zone of the root. In the structure of the surface, strands of microfibrils are visible and accumulation of mucilage. *Triticum vulgare* Host. Magnification ×7020

of local swelling on the root surface in the first stage of root hair development can be followed by scanning electron microscopy (Fig. 9). In wheat, as a consequence of root hair development, the outer layer of the trichoblast cell wall breaks [7, 8]. Them, this ruptured layer of the outer trichoblast wall is folded back, as a rule, to one side of the break. During the subsequent steps of root hair development the ruptured and lifted part of the outer layer of the cell wall apparently dies and it is released from the cell surface. At the base of the fully developed root hairs it can be seen any more (Fig. 12). The break of the outer layer of the cell wall takes place only after the break of the inner fibrillar layer. The breaks in the inner, fibrillar layer are visible by transmission electron microscopy, as reported in the earlier literature. In line with these data, the inner fibrillar layer is absent almost along the whole root hair and it may be observed only in its basal region. The break of the outer layer of the cell wall is associated with the break of the layer of mucilage, that of the cuticle, and of the adjoining pectin matrix with its more or less randomly oriented cellulose microfibrils.

In corn, in the course of root hair formation, a break of the outer layer of the outer cell walls is not observed. However, this does not mean that such a phenomenon does not occur at all. (Sometime it is absent also in the wheat rhizodermal cells.) Perhaps in these cases the ruptured outer amorphous layer of the trichoblast cell wall is closely associated with the wall of the growing root hair. However, the possibility of different mechanisms of root hair formation in different plants can not be excluded at present.

The surface of the root hair is uneven throughout its whole length. The surface of the root tip is friable. Hollows, mucilaginous protrusions and globules can be seen in this region (Fig. 13). It is suggested that the material deposited on the root hair surface is secreted through similar hollows [7]. An intensive secretion of mucilaginous globules on the surface of root hairs has been revealed also by time-lapse cine-photo-micrography [11]. The mucilaginous layer covering the root tips often forms characteristic "caps" (Fig. 13). In such cases, both with wheat and corn, the basal part of the root hair is thinner than the tip (Fig. 14). The surface of the root hairs close to their basal regions seems denser and has a structure which is similar to that of the external surface of the corresponding root zone.

In conclusion, it seems necessary to stress the absence of any major difference in the structure of the external surface of the outer cell walls of wheat and corn. However, by means of scanning electron microscopy, it proved possible to reveal differences in the structure of the external cell surface of the root and demonstrate a gradient associated with "maturity", i.e. to show an increase in density of the structural elements of the external surface of the root hair and that of the root itself towards their basal regions.

Fig. 9. The early phase of root hair development. *Zea mays* L. Magnification ×7020

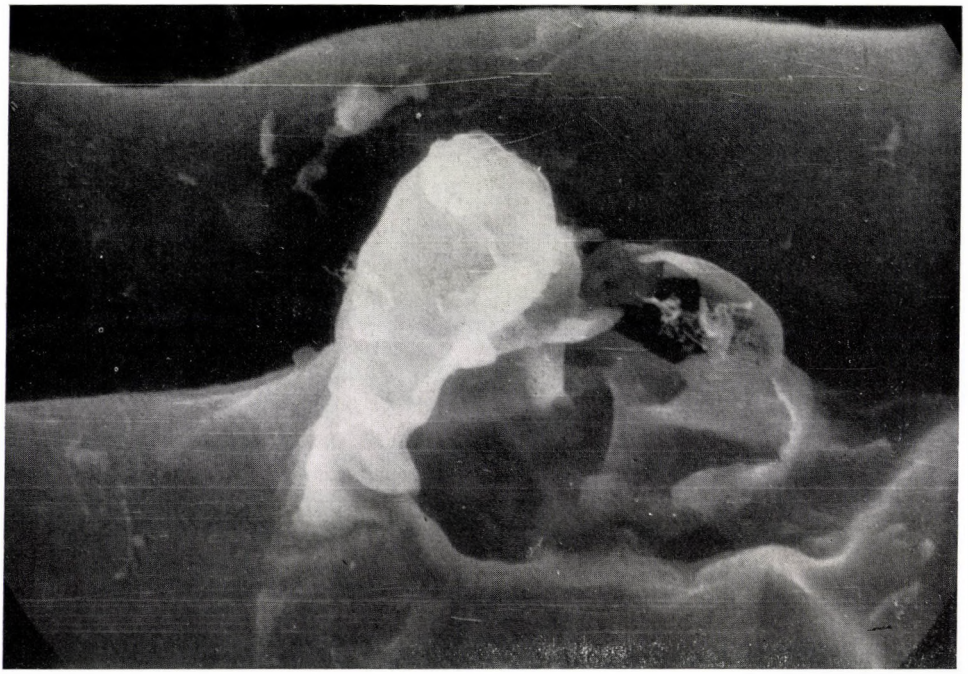

Fig. 10. Breaks in the outer layer of the external cell walls during the formation of root hairs. *Triticum vulgare* Host. Magnification ×2340

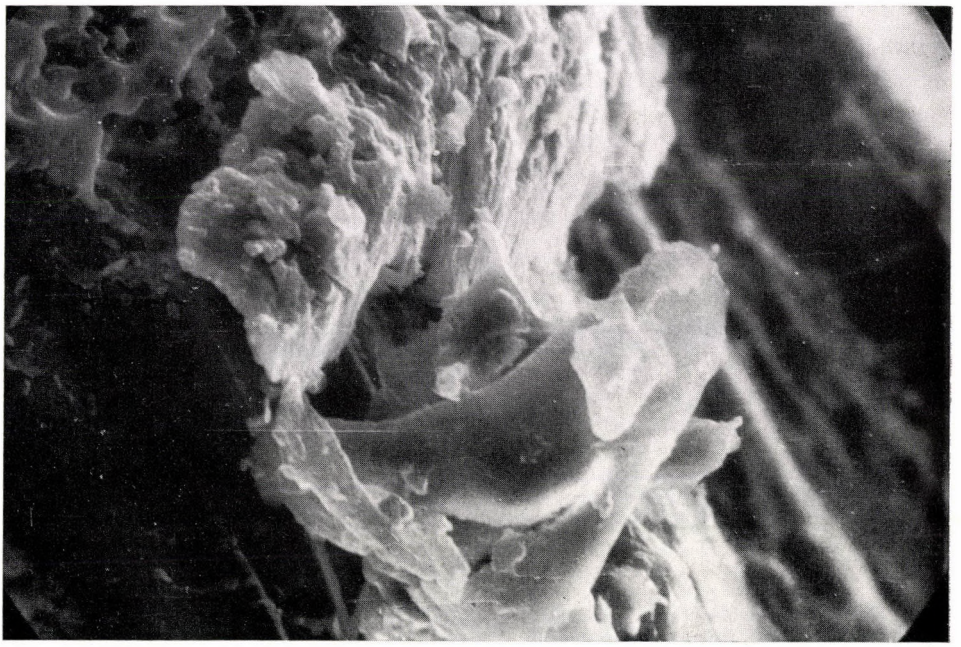

Fig. 11. Parts of the ruptured, outer wall are lifted during root hair development and folded back to one side of the rupture. On the inner surface of the wall, folded back, fibrillar structure may be seen. *Triticum vulgare* Host. Magnification ×1400

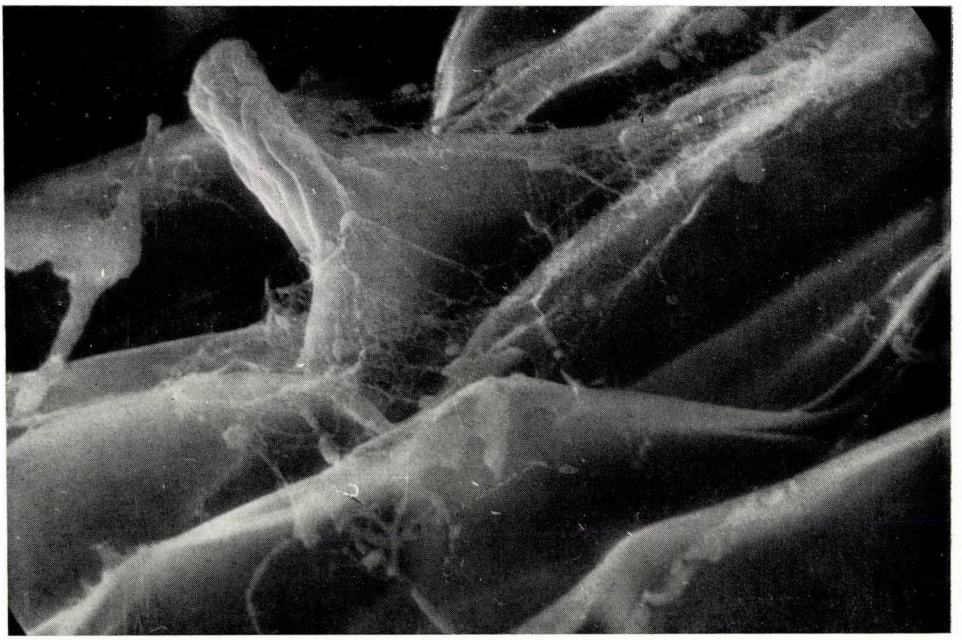

Fig. 12. Development of the root hair. The ruptured layer surrounding the outer cell walls can not be seen at the basal part of the root hair. *Triticum vulgare* Host. Magnification ×1400

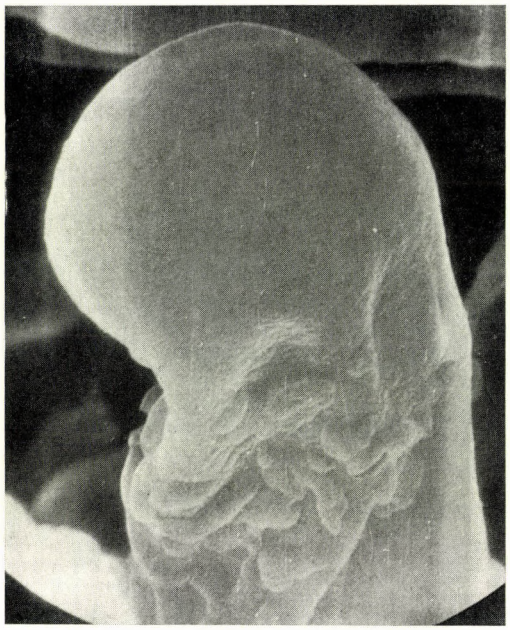

Fig. 13. Surface of the tip of the root hair. The mucilaginous "cap" of the root hairs. *Triticum vulgare* Host. Magnification ×950

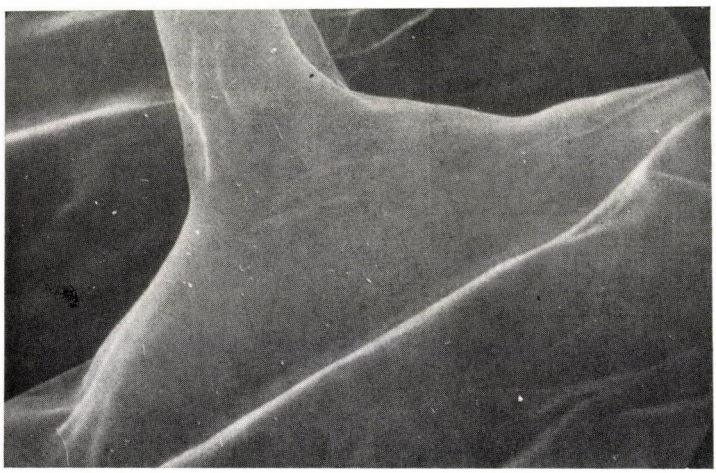

Fig. 14. Surface of the basal part of the root hair. *Triticum vulgare* Host. Magnification ×1750

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MOSS ECOLOGICAL INVESTIGATION IN THE FOREST-STEPPE ASSOCIATIONS OF THE IBP-AREA AT CSÉVHARASZT

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Sampling has been carried out in the following xerothermous associations: *Brometum tectorum*, *Festucetum vaginatae*, *Festucetum wagneri*, *Astragalo-Festucetum sulcatae*, *Junipero-Populetum*, *Festuco-Quercetum*, *Convallario-Quercetum*. The soil samples (about 200) were taken from the moss cushions. The pH-values (in H_2O) and the humus, $CaCO_3$, NH_3, NO_2^-, NO_3^-, P_2O_5 and K_2O contents were determined by prompt analytical (so-called half-micro-) methods. The annual mean value of precipitation on the sample area is 500—550 mm, the average annual temperature reaches 10—11°C. The bedrock is built up by calcareous sand. The cushions of terricolous mosses play an important role in the productive layer of these sandy ecosystems, a fact evinced also by their quantity. Values of the investigated soil characteristics and of the general cenologicoecological behaviour of each studied species are submitted, followed by an analysis of the bryoecological groups of species and of the studied soil characteristics. The pH-values of xerophytous species are related to neutral and basic intervals, those of xero-mesophytous species to neutral, and those of mesophytous species to neutral and acidic, intervals.

The humus values of xerophytous species are lower, those of mesophytous ones higher. The values of NH_3 increases along the gradients from the xerophytous species to the mesophytous ones. Similar conditions appear in the case of NO_2^- and NO_3^-. Regarding the groups of species, the distribution of phosphorus and potassium does not show any regularities. Reference to the seasonal character of some of the characteristics is also given.

Introduction

During our production biological investigations (SIMON, 1971; K. LÁNG—SZABÓ, 1971, etc.), carried out in the IBP model area at Csévharaszt, data were obtained on the moss-lichen synusia of grassy plant associations (Fig. 1). These data indicated the importance of cryptogamous vegetation and its great part in the productive layer of sandy ecosystems. Previous (BORBÁS, 1886; GYŐRFFY, 1943; SOÓ, 1956; BOROS, 1968; SIMON—K. LÁNG, 1972) qualitative or phytogeographical and phytocenological data as well as ecological observations also referred to their frequency and their considerable cover in some places. GYÖRFFY's study, containing a great number of ecological observations on Bugac, is of particular value (1943). In this study, the author elucidates the sand-binding role of the association with *Tortula ruralis*.

The necessity of studying the soil indicating role of sandy moss cushions now became obvious. The investigation of their relations to given soil characteristics and site factors and of their behaviour, respectively, led in several cases (e.g. APINIS—LACIS, 1934—5; WALDHEIM, 1947; BIRSE—GIMINGHAM, 1955; BIRSE—LANDSBERG—GIMINGHAM, 1957; WILLIS, 1964; SIMON, 1970; TARKHOVA, 1970; STRASSER, 1971; PFADENHAUER, 1971; KUEHNER, 1971) to valuable observations both in theoretical and practical respects.

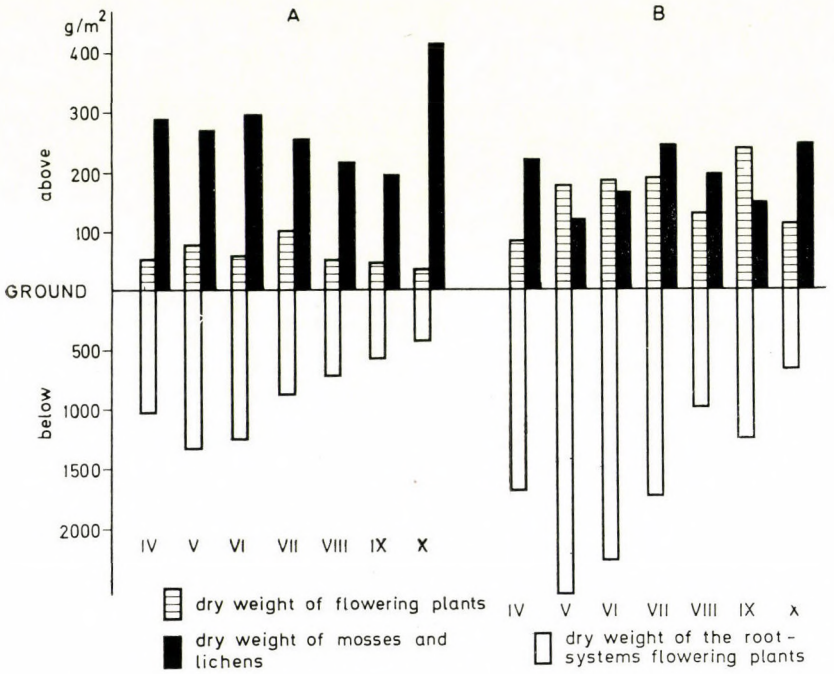

Fig. 1. Changes in the phytomass of sandy grassland communities during the vegetation period (1968). A = *Brometum tectorum*, B = *Festucetum vaginatae danubiale*

Sample area and method

Sample area and phytocenoses. The investigation took place in the Nature Conservation Area at Csévharaszt and in its environment, an area lying in the plains between the Danube and the Tisza, SE of Budapest, at a distance of about 50 km from the capital. There occurs here a forest-steppe vegetation on the sand dunes and swampy, swampy-meadow, resp. meadow vegetations, further relict stands of willow bogs between the dune series, in the filled up former river-beds of the Danube. The former — higher — riverside is lined with *Convallario-Quercetum* stands and the relicts of swampy oak forests.

The annual mean of precipitation amounts to 500—550 mm in the area, the annual average temperature is 10—11°C. The bedrock is built up of calcareous sand poor in nutrients, the average pH-value reaches 7.5—8. Sampling of the moss cushions took place in the forest-steppe community of the area with sand dunes. These may be considered as the relatively stable steps of the xeroseries of sandy succession (Fig. 2). Their stability is particularly due to edaphic (drop of the water table) and partly to climatic (sometimes strong continental effects) and biotic (burning, grazing) factors.

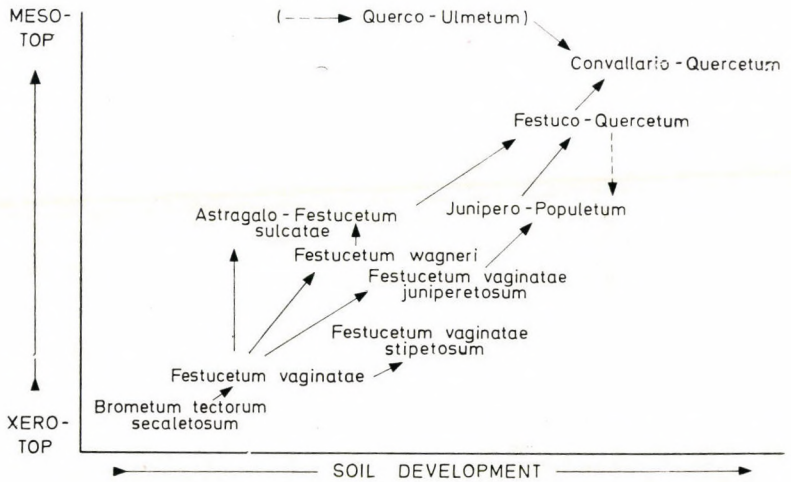

Fig. 2. Succession of the xeroseries of natural plant communities in the Nature Conservation Area at Csévharaszt. The dotted lines denote degradation. *Querco-Ulmetum* does not exist today, its former stands developed — owing to a drop of the watertable — into *Convallario-Quercetum*

Grass land communities: *Brometum tectorum secaletosum* grows on xerothermous, open sites, the type itself is rather secondary (clearing of robinia forests). Mosses occuring frequently are *Brachythecium albicans*, *Bryum argenteum*, *Ceradoton purpureus*, *Tortula ruralis*. *Festucetum vaginatae danubiale:* perennial, open grassland community of dry and warm sites. Its typical mosses are (beside the former ones): *Tortula ruralis*, *Tortella inclinata*, *Homalothecium lutescens*, *Abietinella abietina*, *Hypnum cupressiforme* (preponderantly in northerly exposure in masses), *Encalypta contorta*, *Pleurozium schreberi*, *Polytrichum juniperum*, *Pseudoscleropodium purum* on shaded sites or in northerly exposure). *Festucetum wagneri*, a rather closed grass land community of dry-warm sites — standing cenologically in a close relationship to the former one — shows the following characteristic mosses: *Homalothecium lutescens*, *Brachythecium albicans*, *Hypnum cupressiforme*, *Abietinella abietina*,

etc. *Astragalo-Festucetum sulcatae* generally develops on sunlight sites, in larger clearings and in the marginal parts of forests. It is a completely closed perennial grassland community. Typical mosses: *Abietinella abietina*, *Hypnum cupressiforme*, *Homalothecium lutescens*, *Tortula ruralis* etc. *Junipero-Populetum* has closed stands occuring sporadically in larger or smaller areas and showing moss carpets of a thick acidic medium. It is a site of acidofrequent elements (e.g. *Rumex acetosella)* and of mosses (e.g. *Dicranum scoparium*, *Encalypta contorta*, *Hylocomium splendens* (third datum in the Danube—Tisza Plains (cf. Boros 1968)). *Pleurozium schreberi*, *Polytrichum juniperinum*, *Pseudoscleropodium purum*, *Thuidium delicatulum*. Besides these mosses, also *Hypnum cupressiforme* is abundant and *Ceratodon purpureus*, *Tortula ruralis*, etc. frequent. *Festuco-Quercetum* is a relatively open sandy oak forest community with xerothermous elements. Its characteristic mosses are: *Atrichum undulatum*, *Dicranum scoparium*, *Mnium cuspidatum*, *Hypnum cupressiforme* at the foot of trees (in masses), *Brachythecium velutinum*, *Bryum capillare*. *Convallario-Quercetum* is a more closed high forest community, its mosses are partly identical with those of the former association, its rare species is *Rhodobryum roseum*, and in its stands mixed with pines *(Pinus nigra*, *P. silvestris)* a particularly rich moss carpet appears.

Method. Nearly 200 soil samples of the investigated moss species (19) — taken from the soil of moss cushions in June and July 1970 — have been analysed with quick methods (pH-value from diluted solution, humus content, ammonia, nitrite, nitrate, phosphorus, lime ($CaCO_3$) contents). Each sample had a volume of about 2.5 cm^3. The determination of the pH-value was made by means of a "Radelkisz" electric pH-measuring instrument, type OP 201/1, with a hydrogen electrode. The determination of the humus content was carried out by the Tjurin-colorimetrical method modified by Székely (1964). The values were estimated — together with those of pH and carbonate — according to Stefanovits (1956). Humus: below 1 percent = humus poor; 1.1—2 per cent = humiferous; 2.1—6 per cent = humus rich; pH: below 5.5 = acidic; 5.5—6.6. = slightly acidic; 6.6—7.4 = neutral; 7.4—8.5 = mildly basic; $CaCO_3$: between 0—2 per cent = poor in lime; 2—5 per cent = slightly calcareous; 5—20 per cent = calcareous.

The quantity of N-compounds and mineral substances has been estimated colorimetrically (by means of the Szelényi-colour scales) from an extract obtained by sodium acetic acid. Ammonia nitrogen has been investigated by shaking 1 percent borax solution with Seignettesalt solution and by treating it with Nessler reagent, while nitrite-nitrogen has been treated with nitrite I- and nitrite II-reagents, nitrate-nitrogen has been examined by mixing 10 percent sulphuric acid and 1 percent carbamid solution and by treating it with concentrated sulphuric acid and chloroformic brucine doses. Conclusions have been drawn — also on the basis of colouring — on the quantity of P_2O_5 by

application of ammonium molybdate and stannous chloride solution. The determination of K_2O has been carried out with SZÉKELY's turbidi-colorimetrical method. The value of $CaCO_3$ was obtained — on the basis of the loss of weight — from 10 g soil treated with 10 percent hydrochloric acid (mrs. SÁTORY in SZÉKELY, 1956).

The values obtained during the investigations and noted in the tables are percent value concerning humus and carbonate; the data on ammonia, nitrite and nitrate are mg values relating to 100 ml soil, the data on phosphorus and potassium are mg values relating to 100 g soil (see in detail: SZÉKELY, 1956).

The statistical evaluation of the data (mean value = $\bar{X}$, standard deviation of data = s, standard error of mean value = $s_{\bar{X}}$) and the test of significance have been done by the help of the usual procedures (SVÁB, 1973).

To interpret the results in a more comprehensive way, the investigated species were grouped (according to BOROS, 1968) — by taking into account their water demand — into the following ecological groups:

Xerophytous species:
Abietinella abietina
Brachythecium albicans
Bryum argenteum
Ceratodon purpureus
Encalypta contorta
Homalothecium lutescens
Tortella inclinata
Tortula ruralis

Xeromesophytic species:
Dicranum scoparium
Hypnum cupressiformae
Polytrichum juniperinum

Mesophytous species:
Atrichum undulatum
Brachythecium velutinum
Bryum capillare
Mnium cuspidatum
Pleurozium schreberi
Polytrichum attenuatum
Pseudoscleropodium purum

Helohygrophytic species:
Amblystegium riparium

Results

The characterizations are given on the basis of pH, humus, carbonate, ammonia, etc. values measured in the soil samples taken from the moss cushions (Tables 1, 2, 3). Taking the total into consideration, it may be stated that the studied organic or unorganic compounds are represented in the samples — in an absolute sense — by small or moderate (P_2O_5, $CaCO_3$) quantities. In the case of humus and carbonate (and of pH) the values are expressed according to the STEFANOVITS' scale (see subsection: "Method"). In all other cases (unorganic N-compounds, P_2O_5, K_2O) the given level low, moderate, high) is relative, for it is defined in relation to the data of other species investigated.

Table 1

The mean values and standard errors of some chemical properties in the moss cushion's soil

Mosses	N	pH		Humus		$CaCO_3$		K_2O	
		Mean $\overline{X}$	Standard error of mean ±	Mean $\overline{X}$	Standard error of mean ±	Mean $\overline{X}$	Standard error of mean ±	Mean $\overline{X}$	Standard error of mean ±
Xerophyta									
Abietinella abietina	10	7.2	0.04	0.67	0.15	6.2	0.33	2.9	0.52
Brachythecium albicans	6	7.4	0.35	0.59	1.17	6.0	0.30	3.6	0.34
Bryum argenteum	5	7.7	0.16	0.10	0.06	7.7	0.35	2.0	0.70
Ceratodon purpureus	25	6.2	0.08	0.25	0.04	3.8	0.34	3.9	0.19
Encalypta contorta	10	7.7	0.14	0.52	0.08	7.5	0.36	4.2	0.46
Homalothecium lutescens	4	8.1	0.08	0.61	0.08	7.6	0.43	3.5	0.32
Tortella inclinata	20	7.4	0.10	0.23	0.14	5.5	0.24	4.5	0.51
Tortula ruralis	20	7.3	0.12	0.30	0.07	5.5	0.38	4.7	0.64
Xero-mesophyta									
Dicranum scoparium	15	5.8	0.20	0.81	0.14	3.7	0.29	3.4	0.53
Hypnum cupressiforme	10	7.4	0.04	0.95	0.40	7.2	0.34	6.3	0.72
Polytrichum juniperinum	8	6.8	0.16	0.40	0.07	5.9	0.23	3.5	0.40
Mesophyta									
Atrichum undulatum	4	5.4	0.38	1.43	0.38	2.7	0.40	9.0	0.17
Brachythecium velutinum	8	7.5	0.18	2.12	0.20	7.6	0.21	3.7	0.65
Bryum capillare	6	7.1	0.34	1.41	0.16	6.3	0.41	2.0	0.36
Mnium cuspidatum	10	6.7	0.19	2.22	0.21	4.5	0.27	2.9	0.24
Pleurozium schreberi	6	5.3	0.15	0.66	0.10	3.8	0.20	3.8	0.65
Polytrichum formosum	2	5.0	—	1.00	—	2.6	—	3.7	—
Pseudoscleropodium purum	6	6.9	0.06	2.96	0.57	4.1	0.56	3.8	0.71
Helo-hygrophyton									
Amblystegium riparium	4	7.3	0.29	1.85	0.24	5.7	0.29	3.2	0.45

1. Micro-sites of the investigated species

Abietinella abietina. It occurs in each community of the dry sandy succession series; *Astragalo-Festucetum sulcatae* and the marginal parts of the stands *Junipero-Populetum* and *Festuco-Quercetum* may be regarded as optimum. It is humus-forming. The soil is neutral to mildly basic, calcareous humus poor humiferous. It does not occur in open grasses without humus. It

Table 2

The mean values and standard errors of the measured data of N and P compounds in the moss cushion's soil

Mosses	N	NH_3		NO_2		NO_3		P_2O_5	
		Mean $\overline{X}$	Standard error of mean $\pm$	Mean $\overline{X}$	Standard error of mean $\pm$	Mean $\overline{X}$	Standard error of mean $\pm$	Mean $\overline{X}$	Standard error of mean $\pm$
Xerophyta									
Abietinella abietina	10	0.17	0.090	0.011	0.003	1.3	0.03	2.05	0.27
Brachythecium albicans	6	0.06	0.020	0.008	0.003	1.6	0.32	1.91	0.15
Bryum argenteum	5	0.04	0.022	0.005	0.004	0.8	0.28	3.80	0.11
Ceratodon purpureus	25	0.07	0.016	0.008	0.000	1.3	0.02	2.20	0.14
Encalypta contorta	10	0.07	0.017	0.007	0.003	1.8	0.03	3.20	0.30
Homalothecium lutesceus	4	0.06	0.037	0.007	0.004	1.5	0.41	2.33	0.21
Tortella inclinata	20	0.06	0.020	0.004	0.000	0.8	0.24	2.20	0.20
Tortula ruralis	20	0.05	0.014	0.005	0.001	0.9	0.04	2.51	0.27
Xero-mesophyta									
Dicranum scoparium	15	0.22	0.050	0.008	0.001	1.3	0.04	1.48	0.21
Hypnum cupressiforme	10	0.15	0.028	0.010	0.001	1.9	0.21	2.80	0.22
Polytrichum juniperinum	8	0.09	0.015	0.008	0.003	1.6	0.31	1.93	0.25
Mesophyta									
Atrichum undulatum	4	0.27	0.170	0.009	0.000	3.1	0.01	1.75	0.25
Brachythecium velutinum	8	0.28	0.019	0.016	0.001	2.7	0.30	2.50	0.13
Bryum capillare	6	0.30	0.064	0.021	0.010	1.6	0.13	2.91	0.34
Mnium cusuidatum	10	0.27	0.190	0.021	0.006	2.3	0.22	2.95	0.17
Pleurozium schreberi	6	0.12	0.029	0.009	0.010	1.6	0.22	0.91	0.04
Polytrichum formosum	2	0.22	—	0.010	—	0.5	—	2.25	—
Pseudoscleropodium purum	6	0.27	0.083	0.021	0.010	2.3	0.04	2.95	0.29
Helo-hygrophyton									
Amblystegium riparium	4	0.25	0.116	0.017	0.001	2.3	0.46	2.12	0.23

shows a nitrate content of moderate level, the intervals of ammonia and nitrate are great; in the samples of the open grasses N is often missing. The values of phosphorus and potassium are higher than average.

Brachythecium albicans. Typical species of the open grasses; it reaches its optimum also in the marginal parts of *Festucetum vaginatae* and *Junipero-Populetum;* it is humus-forming. The soil is neutral to mildly basic, calcareous.

Table 3

The extreme values of soil's chemical properties in the moss cushions

Species	pH	Humus	NH_3	NO_2^-	NO_3^-	P_2O_5	K_2O	$CaCO_3$	N
Abietinella abietina	6.5—7.8	0—1.25	0—0.75	0—0.025	0—2.5	1.0—3.0	1—3	5.0—7.9	10
Brachythecium albicans	7—7.7	0.25—1.25	0—0.15	0—0.025	0.5—2.5	1.5—2.5	3—5	4.5—6.9	6
Bryum argenteum	7.3—8.3	0—0.25	0—0.10	0—0.012	0—1.5	3.5—4.0	1—5	7.0—9.1	5
Ceratodon purpureus	5.5—7.1	0—0.75	0—0.25	0—0.050	0—3.0	1.5—4.0	1—5	2.1—6.5	25
Encalypta contorta	7.2—8.4	0.25—1.00	0—0.15	0—0.017	0—2.5	1.5—4.5	2—7	5.8—8.9	10
Homalothecium lutescens	7.9—8.4	0.25—1.00	0—0.15	0—0.015	0.5—2.5	1.5—3.0	2—5	6.5—9.1	4
Tortella inclinata	6.8—8.1	0—0.75	0—0.20	0—0.015	0—3.0	1.5—4.0	2—8	4.0—9.7	20
Tortula ruralis	6.4—8.2	0—1.00	0—0.25	0—0.020	0—2.5	0.5—3.5	1—8	2.0—8.8	20
Dicranum scoparium	4.5—6.8	0—1.75	0—0.75	0—0.050	0—2.5	0.5—3.0	1—7	0.9—5.0	15
Hypnum cupressiforme	6.2—7.4	0.25—1.75	0—0.25	0—0.020	1.0—2.5	2.0—5.0	2—8	4.8—8.8	10
Polytrichum juniperinum	6.1—7.0	0.25—0.75	0—0.20	0—0.015	0.5—2.5	1.0—3.0	2—5	5.0—6.7	8
Atrichum undulatum	5.2—5.8	1.25—1.75	0—0.75	0—0.012	0—5.0	1.0—2.5	6—7	1.1—3.1	4
Brachythecium velutinum	6.9—8.2	1.00—3.00	0.20—0.40	0.010—0.025	1.0—4.0	2.0—3.0	2—7	7.0—8.9	8
Bryum capillare	6.9—7.5	0.75—2.00	0.10—0.50	0.010—0.030	1.0—3.0	1.5—4.0	1—3	5.0—7.5	6
Mnium cuspidatum	5.8—7.2	1.25—3.25	0—0.75	0—0.075	1.5—3.5	1.5—5.0	3—5	2.1—6.8	10
Pleurozium schreberi	4.7—5.8	0.25—1.00	0—0.20	0—0.015	1.0—2.5	0.5—1.5	3—4	2.4—3.9	6
Polytrichum formosum	5.0—5.1	0.75—1.25	0.20—0.25	0.005—0.015	0.4—0.5	0.5—2.0	3—4	2.5—2.8	2
Pseudoscleropodium purum	6.3—7.6	2.50—3.75	0.15—0.30	0.015—0.025	0.5—3.5	1.0—2.5	2—7	3.2—6.0	6
Amblystegium riparium	6.8—7.8	1.50—2.50	0.10—0.50	0.012—0.020	1.5—3.0	1.5—2.5	2—4	5.2—6.5	4

Ammonia and nitrite show a moderate level, while that of nitrate is rather high; phosphorus and potassium show a similar level.

Bryum argenteum. It is a pioneer species in dry, warm and sunlit grasses on unbound sand, a pioneer mostly in disturbed *Festucetum vaginatae.* Its soil is humus poor, mildly basic, calcareous. Ammonia is significant, the average level of nitrite and nitrate is higher than moderate, the level of phosphorus is high, that of K varying.

Ceratodon purpureus. It is common in grasses and in *Junipero-Populetum;* it occurs most frequently in open grasses. The soil is humus-free or humus poor, from slightly acidic to mildly basic, from slightly calcareous to calcareous. The interval of N-compounds extends from zero to relatively high values, phosphorus and potassium vary, their average value is high. On very dry sites it develops hard (also when wet) dark green carpets of a thickness of 4—5 cm, being generally infertile. On fresh sites it reaches 1—2.5 cm, showing (also when wet) a yellowish-green colour; its cushion is looser and brings sporogonia in great quantities. It is an important sand-binder.

Encalypta contorta. A moss of shaded *Festucetum vaginatae* and *Junipero-Populetum* stands. Its soil is mildly basic, calcareous humus poor, but always containing some humus. The level of ammonia and nitrite is moderate, that of nitrate high. Phosphorus and potassium show a high level. The species is not frequent. It does not bring sporogonia.

Homalothecium lutescens. Relatively rare in the area; it occurs in open and in closed grasses. Its soil is mildly basic, calcareous and humus poor. The level of ammonia is low, that of nitrite and nitrate moderate. The average level of phosphorus and potassium is relatively high.

Tortella inclinata. It is one of the most frequent species of open grasses, developing large cushions. It often fills in spaces between clumps of grass, thus initiating coverage. It occurs also in *Junipero-Populetum* and *Astragalo-Fesctucetum.* It grows in great masses on protected sites, where also sporogonia are frequent (e.g. *Festucetum vaginatae salicetosum rosmarinifoliae).* Its soil is neutral to midly basic, calcareous, humus-free or humus poor (of the humic acids a slight overweight of fulvic acids is characteristic: SIMON—K. LÁNG 1968). The average level of ammonia is low, as also that of both nitrite and nitrate, they are even completely missing from the major part of the samples. The average level of phosphorus and potassium is relatively high.

Tortula ruralis. A pioneer species of the open grasses covering the largest area and often developing independent — extensive — stands. A binder of blown or disturbed sand; its shallow, loose grasses appear also on N-free soil. Its soil is slightly acidic to mildly basic, from mildly calcareous to calcareous, humus-free or poor in humus. The average level of ammonia is low, that of nitrite and nitrate moderate. Phosphorus and potassium are always traceable, their average level is relatively high, the values of the latter vary considerably.

Dicranum scoparium. This typical species of our calcifuge montane and hilly forests occurs surprisingly often in calcareous sandy steppes, growing particularly it occurs also in *Festucetum vaginatae* — mostly on the top of or between the dunes — where the occurence of shrubs refer to the former existence of forest soil. Several sites are to be found in *Festuco-Quercetum* (e.g. together with *Polygonatum odoratum)* or in cultivated pine stands *(Pinetum nigrae* et *silvestris* cultum), owing to similar reasons (forest soil pine-needle litter). The species reaches its optimum in *Junipero-Populetum* and *Pinetum* cultum, respectively, developing here 7—9 cm thick carpets. Its soil is acidic to slightly acidic, lime-free or slightly calcareous humus poor or humiferous. The average level of ammonia is relatively high, that of nitrite and nitrate moderate. The average level of phosphorus is moderate, that of potassium high, but the values of the latter vary considerably.

Hypnum cupressiforme. It occurs to a lesser or greater extent on the soil of each investigated community, yet it shows its optimum in *Junipero-Populetum.* Here it forms contiguous and thick cushions. It prefers half-shaded sites. On its optimal sites one may observe the fungal decomposition of the lower part of the cushion. It prefers half-shaded sites. On its optimal sites one may observe the fungal decomposition of the lower part of the cushion. Its soil is slightly acidic to neutral, mildly calcareous to calcareous humus poor humic. The average level of ammonia is moderate, that of nitrite and nitrate likewise. It shows relatively high phosphorus and potassium levels, only the latter has a wide interval of values.

Polytrichum juniperinum. It is relatively frequent, occuring first of all in *Junipero-Populetum*, but growing also in *Pinetum* cultum and *Convallario-Quercetum.* Its soil is slightly acidic to neutral, slightly calcareous and humus poor. The level of ammonia is moderate, that of nitrite and nitrate likewise; the level of phosphorus is moderate, but potassium shows a high level. As a species of calcifuge forests and growing principally on acidic rock outcrops, it only vegetates on calcareous sandy steppes; here its cushion is shallow and it grows often thread by thread. It does not bring sporogonia.

Atrichum undulatum. It is a relatively rare species, occuring in the more shaded stands of *Festuco-Quercetum*, in *Convallario-Quercetum* and cultivated *Pinetum.* Its soil is acidic to slightly acidic, practically lime-free, humiferous. The average level of ammonia is relatively high, that of nitrite moderate and that of nitrate relatively high. Phosphorus shows a moderate level, potassium a high one. The micro-sites are fresh, development of the species is normal and it brings sporogonia.

Brachythecium velutinum. It grows on the soil of *Festuco-Quercetum* and *Convallario-Quercetum*, but threadwise it occurs also in *Festucetum vaginatae*, *Festucetum wagneri* and *Junipero-Populetum.* Its soil is neutral to mildly basic, calcareous humiferous or humus rich! The level of ammonia

is relatively high and so is the level of nitrite, nitrate, potassium and phosphorus.

Bryum capillare. It occurs frequently on the soil (also at the foot of trees) of *Festuco-Quercetum* and *Convallario-Quercetum.* Its soil is neutral, mildly basic, calcareous humus poor or humiferous. The average level of ammonia is relatively high, that of nitrite likewise; nitrate shows a moderate level, phosphorus a high potassium a moderate one. It develops well and brings sporogonia (June—July).

Mnium cuspidatum. Its sites are to be found mostly in the stands of *Convallario-Quercetum* or in the marginal parts of these, but sporadically it also occurs in *Junipero-Populetum.* Its soil is slightly acidic or neutral, slightly calcareous humiferous or humus rich!). The average level of ammonia is moderate, but in some of the samples outstandingly high, that of nitrite and nitrate relatively high. Phosphorus shows a high, potassium a moderate level, the standard error of mean of the latter is small. Its high humus content adsorbs moisture, thus its micro-sites are always fresh. In some years it brings much sporogonia, whereas in others only very few.

Pleurozium schreberi. Relatively frequent in the Nature Conservation Area, but it grows exclusively in *Junipero-Populetum* in extended and 10—30 cm thick cushions. It also occurs in several places in *Pinus* stands. Its soil is acidic, slightly acidic, slightly calcareous and humus poor. The average level of ammonia is moderate, that of nitrite and nitrate similarly; the level shown by phosphorus is low and that of potassium high.

Polytrichum formosum. This rare species occurs in *Convallario-Quercetum* and *Pinus* stands. It is a typical acidofrequent species of calcifuge forests, known in the territory between the Danube and the Tisza only from a single site (Ócsa). Its soil is acidic, somewhat calcareous humus poor or humiferous. The average level of ammonia is relatively high, that of nitrite and nitrate moderate. Potassium shows a high and phosphoreous a low level.

Pseudoscleropodium purum. Occurs sporadically in *Convallario-Quercetum* and *Junipero-Populetum* and grows in masses in some places of cultivated *Pinus* stands. Its soil is neutral, slightly calcareous and humus rich. The average level of ammonia is relatively high, that of nitrite and nitrate similarly. Phosphorus shows a moderate and potassium a high level — the values of the latter ranging on a wide scale.

Amblystegium riparium. The samples originate from *Convallario-Quercetum robinietosum* having fresh soil and deeper lying sites. It is also common in the communities of the hygroseries of the area *(Caricetum elatae, Caricetum acutiformis-ripariae, Agrosteum albae, Alopecuretum pratensis,* etc.). Its soil is neutral, slightly calcareous, humiferous. The average level of ammonia is relatively high and so is the level of nitrite, nitrate, phosphorus and potassium.

2. *Description of the sites of the ecological groups of species*

With regard to the investigated characteristics, we may compare the species grouped according to their site requirements, that is, the ecological groups of species. This grouping (BOROS, 1968) has been carried out by taking into consideration the experiences collected during several decades, the results of investigation and the results obtained abroad.

pH-value. It ranges within a very wide interval in the moss cushions growing on different sites of the Nature Conservation Area (4.5—8.4). The lower values may be found mostly by mesophytous species, the higher ones by

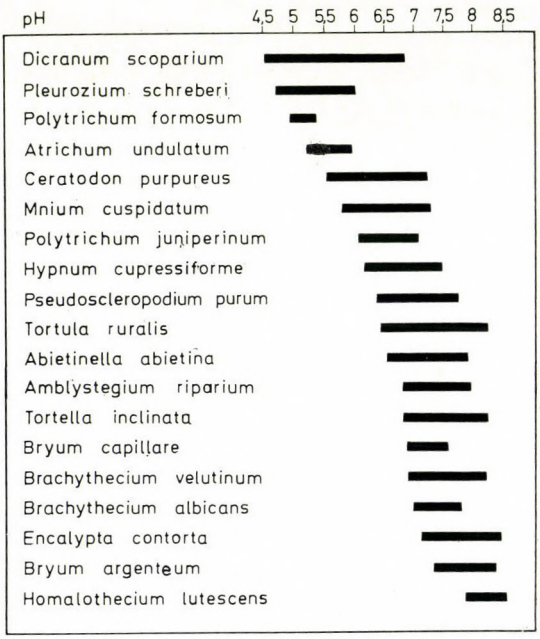

Fig. 3. Intervals of pH-values

xerophytous species. The average of mean values of the species belonging to the different groups show a definite difference (Fig. 4). The mesophytous species significantly differ from the xerophytous ones (Table 4).

As for the chemical and physico-chemical properties of soil, their seasonal changes are well-known. We studied the seasonal changes of the pH-value by *Tortula ruralis* and *Dicranum scoparium*. The values showed — according to the Hungarian type of climate — a peak in the summer (cf. also SIMON—FÜLÖP, 1966). The degree of oscillation was on the average, 0.2 *(Tortula)* and 0.3 *(Dicranum)*, respectively (Fig. 5).

Table 4

Comparison of the averages of mean values of xerophytic (N = 8) and mesophytic (N = 8) species by t-test

	pH	Humus	$CaCO_3$	K_2O	MH_3	NO_2^-	NO_3^-	P_2O_5
Mean values								
xerophytes	7.4	0.41	6.2	3.7	0.07	0.007	1.2	2.52
mesophytes	6.3	1.72	4.5	3.9	0.25	0.016	2.2	2.27
Calculated *t*-value	2.77	4.84	2.22	0.24	6.96	3.91	2.64	0.73
$SD_{P5\%}$	0.9	—	1.8	2.0	—	—	0.8	0.81
$SD_{P1\%}$	—	0.95	—	—	0.09	0.008	—	—

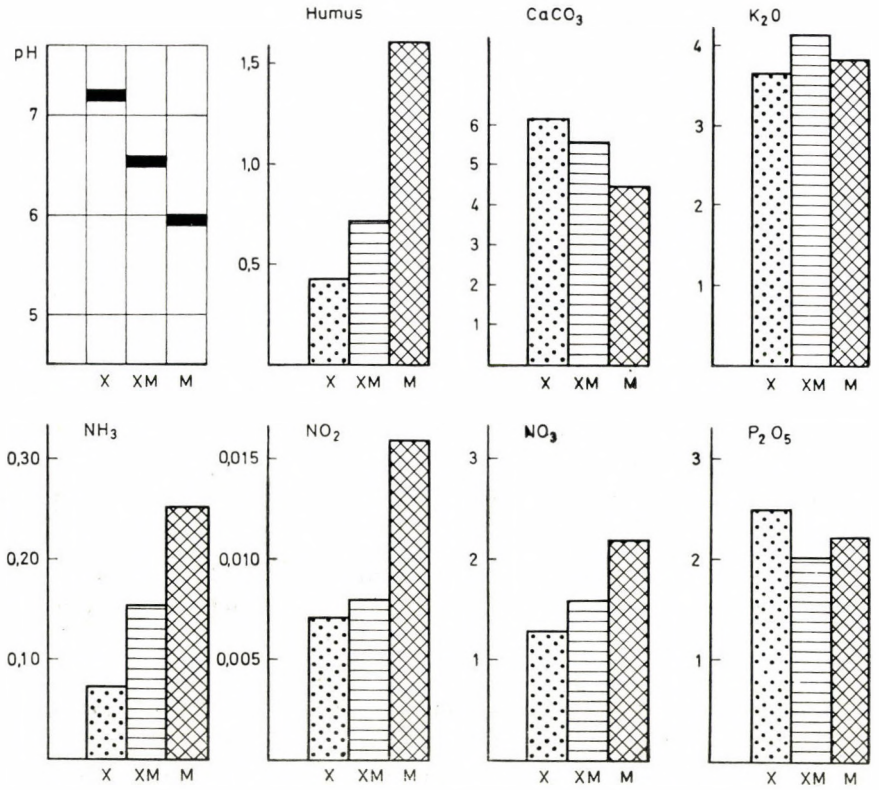

Fig. 4. Comparative diagram of the ecological groups of investigated species on the basis of the average of mean values (xerophytes = X, xeromesophytes = XM, mesophytes = M)

Humus content. It is relatively low in the investigated area. In the moss cushions it shows the average value of 0.2—2 per cent. Within this range, the difference of the ecological groups of species is very definite. The values of the xerophytous species of pioneer character are low, the average of their mean values reaching 0.4 per cent, that of the xeromesophytes 0.7 per cent and that of the mesophytes 1.6 per cent. The difference between xerophytous and mesophytous species is significant (Table 4). The extremities are represented by the species *Bryum argenteum*, *Tortula inclinata*, *Ceratodon purpureus*, *Tortula ruralis* (xerophytous species with a mean below 0.5 per cent) resp. *Brachypodium velutinum*, *Mnium cuspidatum*, *Pseudoscleropodium purum* (mesophytes with a mean above 2 per cent) (Table 3). The xerophytous

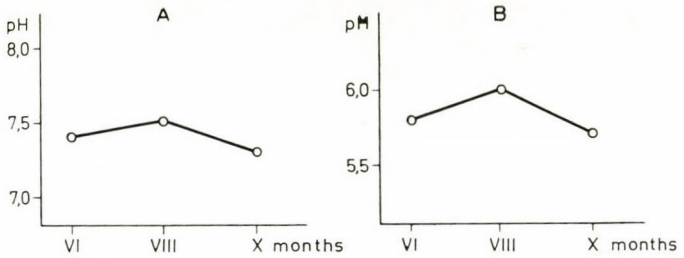

Fig. 5. Seasonal changes in the pH-values in the Reserve at Csévharaszt. A = *Tortula ruralis*; B = *Dicranum scoparium*; the samples were taken from (N = 3) open sandy grasses (A) and *Junipero-Populetum* (B)

pioneers showing low average values often grow even on humus-free sites in great masses. Their organic substances enriches the soil by humification and thus it becomes suitable for the settling of species with a higher demand.

The average of mean values of the species of ecological groups indicate a significant difference (Table 4). The quantity of humus increases in the xeroseries from the open stands towards the closed ones. Also in the samples of the respective species of open grasses there occurs a value approximating or even reaching 1 per cent. This may be explained by the periodical humification of the rich moss synusium.

Investigation of inorganic forms of nitrogen. There exists a close relationship between soil, humus and the level of inorganic nitrogen. Humiferous soils with a good circulation of material show a high nitrate level, while the nitrate and ammonia level of dry soils poor in humus is low. From the ratio of inorganic N-forms one may conclude on the characteristics of biodynamics. A too high level of nitrate and ammonia refers to an unhealthy soil life, to anaerobiosis and the formation of raw humus. Inorganic N-forms play a small role in open grasses, in several cases they are even completely missing. Their level increases parallel with coverage and afforestation.

The values of inorganic N-compounds are in themselves very low. Particularly the amount of nitrite-N and ammonia-N is small, this being characteristic of dry soil poor in organic substances and nutrients. The nitrite-N supply of the soils of moss carpets is somewhat more favourable. It shows (in absolute sense) low to moderate values. Between the nitrate-N average of the three ecological groups — though an increase from xerophytous species to mesophytous one is unambiguous — there is a relatively small difference. The mean value of the xerophytes differ significantly from that of the mesophytes in the case of all three N-forms (Table 4). Sometimes even the samples of xerophytous species (e.g. *Ceratodon purpureus*, *Tortella inclinata*, *Encalypta contorta)* show relatively high values. One may assume in this case that owing to the thickness of their larger carpets they preserve moisture better and have a better adsorption capacity, further they resist to washout and hence also their storage of nitrate is better.

Ammonia-N indicates according to the ecological groups of species — parallel to humus — definite differences.

The average of mean values of xerophytous species amounts to 0.07, that of xeromesophytes to 0.15 and that of mesophytous species to 0.25. As for nitrite-N and nitrate-N, the values of xerophytous and xeromesophytous species are similar, while the mesophytes reach higher values. This refers unambiguously to the fact that in the mesophytous species there begins an accumulation of inorganic N-forms. The level of ammonia-N and nitrite-N of these species refers to fresh humus-forming processes and to surface anaero biosis. These processes are particularly characteristic of *Junipero-Populetum.*

The extremities of inorganic N-forms are to be found in Table 3.

We examined by some species the summer-autumnal changes of Nitrate-N. According to this exploratory study, the level of nitrate-N decreased from July to October by 1 mg on the average (Fig. 6).

Phosphorus and potassium content. In absolute sense the level of phosphorus may be regarded as moderate, whereas that of potassium as low. In the different ecological groups of species none show definite relationships; concerning the average of mean values their distribution may be considered as roughly uniform. Both of them — but especially phosphorus — show a considerable variability in the soil between stable and labile stages, a warning to be cautious in the evaluation of data. They are to be treated therefore as being only informative ones.

Among the xerophytous species, *Bryum argenteum*, *Encalypta contorta* and *Tortella inclinata* may be pointed out as showing a relatively high phosphorus content, among the xeromesophytes *Hypnum cupressiforme* and among the mesophytous species *Bryum capillare* and *Mnium cuspidatum* similarly contain a relatively large amount of phosphorus.

As for potassium, the following species can be mentioned in the above sense: among the xerophytes *Ceratodon*, *Tortula ruralis*, *Tortella inclinata*, *Encalypta contorta*, among the xeromesophytous species again *Hypnum cupressiforme*, among the mesophytes *Atrichum undulatum*, *Brachythecium velutinum* and *Pseudoscleropodium purum*.

Lime content. The soil of the moss cushions show a good supply of lime content expressed in calcium carbonate. In addition, — concerning the ecological groups of species — also the regularity of a decrease of calcium-carbonate content asserts itself, shown by the sites ranging from open grasses to afforestations. The highest averages of mean values are reached by xero-

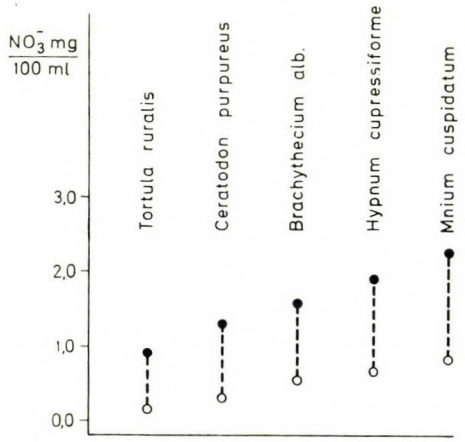

Fig. 6. Seasonal changes in the NO_3-values in the Reserve at Csévharaszt. Full circlets: mean values of the samples taken in August (see Table 3); empty circlets: mean values of the samples collected by the end of October (N = 3)

phytous species, while the xeromesophytous species have lower, and the mesophytes the lowest, values. These differences — though small — can be well identified.

To sum up, it may be stated that, considering the investigated factors, the "empirical" ecological groups of moss species show a more or less delimitable range of interval of values, except for phosphorus and potassium. This leads to the conclusion that adaptation to the given "niches" of the environment is also here a frequent phenomenon and that this becomes realized by the selective matter intake of the species. This means at the same time that, by a more exact determination of the factor species relations, also a more perfect delimiting and system, respectively, of the ecological may be elaborated. This will afford a more effectual informations on the basis of the moss cushion showing various patterns and covering in some places extensive surfaces.

Fig. 7. Dicranum scoparium in the IBP model area at Csévharaszt (Photo: T. Simon)

Fig. 8. Pseudoscleropodium purum in the IBP model area at Csévharaszt (Photo: T. Simon)

Fig. 9. Typical aspect of the Reserve at Csévharaszt. In the foreground *Festucetum vaginatae danubiale*-stands, in the background *Junipero-Populetum* (Photo: T. Simon)

Fig. 10. Detail of the Reserve at Csévharaszt, *Festuco-Quercetum*-relict stand (right background), *Junipero-Populetum* (in the middle) and *Festucetum vaginatae-stipetosum*-stands (in front) (Photo: T. Simon)

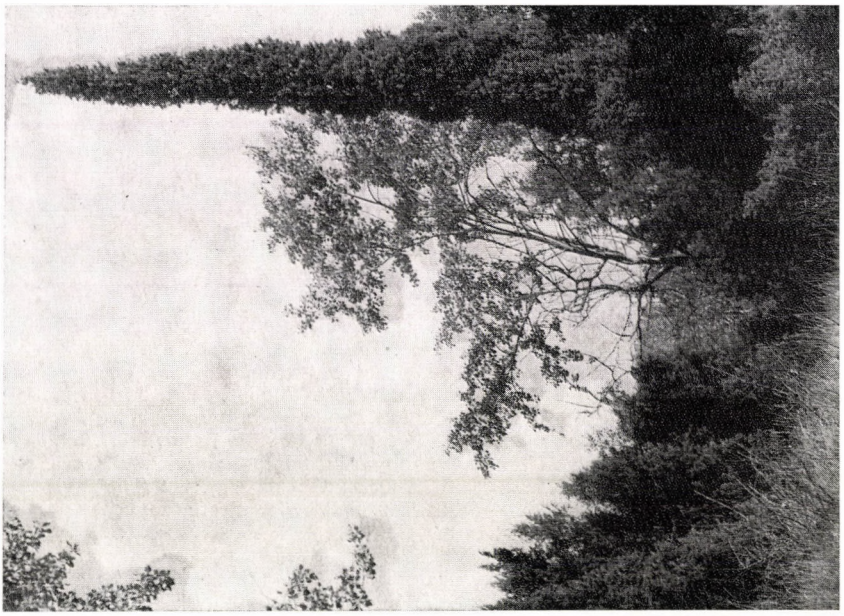

Fig. 12. "Cypress-figured" slender *Juniperus* in the Reserve at Csévharaszt (Photo: T. Simon)

Fig. 11. Junipero-Populetum, in front with *Festucetum vaginatae*

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DATEN ZUR VERERBUNG DES CHAMAZULENGEHALTES IN KAMILLENPOPULATIONEN

Von

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(Eingegangen am 16. April 1974)

In the past 15 years two new varieties of camomile have been produced in Hungary; their active agent is substantially better than that of field populations. The new strains offer a possibility to improve the camasulene content of the salt habitat populations. However, their utilization required a preliminary investigation into some fundamental problems.

The possibilities and extent of hybridization of the wild-growing population of a small inflorescence with the improved species; the fitness of the varieties, their competitiveness in mixed populations; and the course of heredity of camasulene content had to be clarified. The possible substrate effects on the active agent content of the new varieties — when cultivated on soda soil — had also to be examined. The paper discusses the results of investigations of population dynamics.

Die Beurteilung der Kamillen auf Grund ihres Wirkstoffgehaltes hat nach den chemischen Erkenntnissen der letzten 20 Jahre und besonders seit Klärung der biologischen Wirkungen des Chamazulens grosse Bedeutung gewonnen. Diese Erkenntnisse hatten zur Folge, dass man sich in den wichtigeren Produktions- und Vertriebsländern der Kamille, somit auch in Ungarn, die Steigerung des Kamillenwirkstoffgehaltes zur Aufgabe gestellt hat. Mit dem Blick auf diese Zielsetzung führten MÁTHÉ (1960) und MÁTHÉ—TYIHÁK (1960, 1962) im Verlaufe mehrerer Jahre grossangelegte, das ganze Land umfassende Erhebungen durch, um in den ungarischen örtlichen Populationen die Verteilung nach dem Wirkstoffgehalt zu ermitteln. Die Untersuchungen führten zu der Feststellung, dass die Populationen mit dem niedrigsten Chamazulengehalt in den Gebieten mit Sodaböden östlich der Theiss vorzufinden sind. Diese Feststellung ist deshalb besonders schwerwiegend, weil der überwiegende Teil der wildwachsenden Kamille eben aus diesen Gebieten stammt und infolgedessen der durchschnittliche Gehalt der ungarischen Kamillendrogen an ätherischen Ölen mit 0.3—0.6% angegeben wird; das Chamazulen ist unter diesen Ölen mit einem Anteil von 3—6% vertreten (AUGUSTIN, 1937; WILL, 1934; AUSTER—SCHÄFER, 1958).

Weitere Untersuchungen von MÁTHÉ und TYIHÁK (1962) haben erwiesen, dass die Populationen aus diesen Gebieten einen hohen Gehalt an L-α-Bizabolol aufweisen, das ebenfalls eine entzündungshemmende Verbindung darstellt. Die Verfasser haben zugleich auch darauf hingewiesen, dass in den ungarischen Kamillenpopulationen zwischen letzterer Verbindung und dem

Chamazulengehalt eine negative Korrelation besteht. Auf neuere Untersuchungen gestützt, ist aber SCHILCHER (1973) der Meinung, dass diese negative Korrelation nicht gesetzmässig ist.

Zur Förderung der Konkurrenzfähigkeit der ungarischen Kamille auf dem Weltmarkt bieten die Qualitätsverbesserung, d. h. die Erhöhung des Gehalts an ätherischen Ölen und insbesondere an Chamazulen die besten Perspektiven (TÉTÉNYI, 1961). Mit dieser Zielsetzung wurde im Forschungsinstitut für Heilpflanzen im Jahre 1958 die züchterische Bearbeitung der Kamille eingeleitet; über die ersten Ergebnisse hat SÁRKÁNY (1965) berichtet. Züchtungsarbeiten mit Kamille wurden ausserdem an der Universität für Gartenbau von KEREKES geführt. Als Ergebnis der Kamillenzüchtung in Ungarn wurden zwei Neuzüchtungen mit den Sortennamen Budakalászi 2 und Soroksári 40 als staatlich anerkannte Sorten zugelassen (BECKER, 1970). Bei beiden Sorten ist der Gehalt sowohl an ätherische Ölen, als auch an Chamazulen erheblich höher als bei den wildwachsenden Populationen; im Gehalt an ätherischen Ölen von etwa 1% sind 15—17% Chamazulen enthalten.

Diese Züchtungsergebnisse sind an sich auch in praktischer Beziehung von Bedeutung. Zur wirksamen Ausnützung der bereitgestellten Zuchtsorten erwies es sich aber als unerlässlich einige theoretische Fragen zu klären.

Das zu lösende Problem ergibt sich im wesentlichen daraus, dass ein erheblicher Teil der Kamillendroge die Ungarn exportiert von Wildpopulationen der erwähnten Sodaböden stammt. Zur Steigerung des Chamazulengehaltes dieser örtlichen Populationen bietet sich die Möglichkeit einer Übersaat der Sodabödenweiden mit Saatgut der Zuchtsorten. Vor der ausgedehnteren Einführung dieses ziemlich kostenaufwendigen Verfahrens mussten folgende grundlegende Fragen geklärt werden: Möglichkeit und Umfang der Kreuzung der kleinblütigen Wildpopulationen und der grossblütigen Zuchtsorten; Fitnessverhältnisse und Konkurenzfähigkeit der Zuchtsorten in Mischpopulationen; Vererbung der Gehaltswerte. Schliesslich musste ermittelt werden, ob und wie sich der Bodeneffekt auf den Wirkstoffgehalt der neuen Zuchtsorten bei Anbau auf Sodaboden geltend macht.

Material und Methode

Die Versuche wurden mit zwei Kamillentypen eingestellt. Die eine mit I bezeichnete Variante war eine kleinblütige Kamille mit niedrigem, 4%igem Chamazulengehalt, die andere eine grossblütige Kamille mit 17% Chamazulengehalt, die mit II bezeichnet war. Beide Typen blühten zu gleicher Zeit.

Zwei Versuche wurden eingestellt. In dem einen Versuch wurde die Fortpflanzungsdynamik der Mischpopulationen untersucht. Die Ansaat erfolgte mit einem je 50%igen Saatgutgemisch, wobei sich die blühenden Pflanzen frei miteinander kreuzen konnten. Parallel wurden die beiden Typen auch in räumlicher Isolation vermehrt. Aus der ersten und zweiten Nachkommensgeneration sowohl der Mischsaat als auch der isoliert vermehrten beiden Typen wurden je 500 Einzelpflanzen zur Ermittlung der Verteilung der Individuen nach dem Chamazulengehalt geprüft.

Im zweiten Versuch wurden die Kreuzungsverhältnisse zwischen den beiden Typen in abwechselnden Reihensaaten untersucht. Das Saatgut der beiden Typen wurde je 1 Reihe sowie je 2, 3 und 5 Reihen wechselnd, jeweils in 4 Wiederholungen ausgesät. Auf diese Weise hatten wir von jeder der beiden Typen Pflanzenreihen, die den fremden Pollen von beiden Seiten und solche, die ihn nur von einer Seite unmittelbar erhalten konnten. Ausserdem standen im Versuch auch Pflanzenreihen, die von beiden Seiten durch je eine bzw. durch zwei Pflanzenreihen gegen den fremden Pollen abgeschirmt waren.

Sämtliche Pflanzen des Versuches, d. h. die gesamten Nachkommensgenerationen beider Versuche wurden auch mit Pflanzung weitergeführt, das volle Versuchsmaterial konnte somit individuell untersucht werden.

Die erfolgte Kreuzung bzw. der Erbgang wurde aus dem Chamazulengehalt getestet; die EP-Schnellmethode (TYIHÁK, 1962) ermöglichte es uns, die Einzelprüfung einer relativ grossen Zahl in den spektrophotometrisch (6440 A) ermittelten Extinktionswerten anzugeben.

Zur Erfassung des eventuellen Einflusses des Sodabodens auf den Chamazulengehalt wurde die Verteilung der Nachkommensgeneration der Sorte Budakalászi 2 von den angesäten Parzellen mit der Verteilung des durch Pflanzung vermehrten Bestandes der gleichen Sorte verglichen; aus dem letzteren Bestand waren die spontan ausgetriebenen Einzelpflanzen der bodenständigen Wildpopulation entfernt worden.

Dieser Versuch auf Sodaboden wurde in der Station Balmazújváros (ostungarisches Steppengebiet) des Unternehmen HERBÁRIA durchgeführt.

Versuchsergebnisse

Prüfung der Nachkommensgeneration der Mischpopulationen

Die Bestände der mit dem je 50%igen Saatgutgemisch der Typen I und II angesäten Feldversuche wurden zwei Jahre lang weitervermehrt, und die Verteilung nach dem Wirkstoffgehalt ihrer Einzelpflanzen wurde mit der Verteilung der Individuen der Ausgangspopulation verglichen.

Die prozentuale Verteilung der Pflanzen des 4% Chamazulen enthaltenden Typs I und des 17% Chamazulen enthaltenden Typs II — auf Grund der bei Versuchsbeginn mit der EP-Schnellprüfung erhaltenen Farbreaktion — ist in Tabelle 1 angegeben. Die Ergebnisse, die wir nach der gleichen Prüfmethode aus dem in den folgenden zwei Jahren isoliert vermehrten Material erhielten, sind in der Tabelle 2 zusammengefasst.

Nach den Untersuchungsergebnissen der drei Jahre entfielen 85—90% der Pflanzen des Typs I in den gelbe und gelbgrüne Farbreaktionen liefernden, niedrigen Chamazulengehalt anzeigenden Bereich, während von den Pflanzen des Typs II mehr als 85% blaue-dunkelblaue, hohen Chamazulengehalt anzeigende Farbreaktionen ergaben. Die Verteilung nach dem Chamazulengehalt innerhalb der Sorten erwies sich als sehr stabil, wie dies aus den in den Tabellen angegebenen Chi^2-Werten hervorgeht.

Die Nachkommensgenerationen der je 50%igen Mischsaat der beiden Typen wurden über zwei Jahre geprüft. Die Ergebnisse sind in Tabelle 3 angegeben und mit der erwarteten Verteilung verglichen, die sich auf Grund der Ergebnisse der isolierten Vermehrung der beiden Typen ergeben würde, wenn sie sich mit gleicher Fitness, ohne Hybridisation vermehren.

Tabelle 1

Prozentuale Verteilung der Einzelpflanzen nach ihrem Chamazulengehalt bei den geprüften beiden Typen (I und II) zu Beginn des Versuches

Extinktionswerte	Häufigkeitsverteilung der Pflanzen %	
	Typ I	Typ II
0,0—0,2	45	0
0,2—0,4	48	0
0,4—0,6	1	1
0,6—0,8	2	10
0,8—1,0	3	18
1,0—1,2	1	37
1,2—1,4	0	15
1,4—1 6	0	13
1,6—1,8	0	6
Gesamtzahl der geprüften Pflanzen	500	500

Tabelle 2

Prozentuale Verteilung der Einzelpflanzen nach ihrem Chamazulengehalt in den isolierten Vermehrungsbeständen

Extinktionswerte	Häufigkeitsverteilung der Pflanzen %			
	Typ I		Typ II	
	1. Jahr	2. Jahr	1. Jahr	2. Jahr
0 0—0,2	43	53	0	2
0,2—0,4	45	30	0	2
0,4—0,6	1	4	1	2
0,6—0,8	2	1	9	11
0,8—1,0	2	7	16	26
1,0—1,2	3	3	30	37
1,2—1,4	2	1	25	11
1,4—1,8	1	0	6	0
Chi^2	10,56		11,5	

Aus diesen Daten kann festgestellt werden, dass die prozentuale Verteilung der Einzelpflanzen in der ersten Nachkommensgeneration vollständig mit der erwarteten Verteilung übereinstimmt, die sich aus der Summierung der Ergebnisse der beiden Ausgangspopulationen ergab. Der Wert $Chi^2 = 8,2$

beweist, dass die beiden Typen annähernd gleiche Fitness hatten und dass in keiner Richtung eine Verschiebung der Fortpflanzungsrate eintrat. Die zweite Nachkommensgeneration aus der weiteren Vermehrung lieferte ein etwas abweichendes Ergebnis. Im dritten Jahr zeigte nämlich die Verteilung der Mischpopulation eine bei $P = 0.1$ signifikante Abweichung von der summierten, berechneten Verteilung der beiden Ausgangspopulationen, wie sie durch den Chi^2-Wert von 28,2 angezeigt wird (Abb. 1).

Tabelle 3

Prozentuale Verteilung der Einzelpflanzen nach ihrem Chamazulengehalt in der 1. und 2. Nachkommensgeneration der Modellmischsaat im Vergleich zu den summierten Erwartungswerten

Extinktionswerte	Summierte Häufigkeitsprozente der Einzelpflanzen			
	1. Nachkommensgeneration		2. Nachkommensgeneration	
	Erwartung	Beobachtung	Erwartung	Beobachtung
0,0—0,2	43	49	55	23
0,2—0,4	45	50	32	50
0,4—0,6	2	3	6	19
0,6—0,8	11	5	12	23
0,8—1,0	18	20	33	41
1,0—1,2	33	27	40	28
1,2—1,4	27	31	12	11
1,4—1,6	14	7	10	5
1,6—1,8	7	8	0	0
Chi^2	8,2		28,2	

Aus dem Vergleich der erwarteten und der empirisch ermittelten Verteilung kann festgestellt werden, dass sich die Zahl der Pflanzen des Übergangstyps erheblich erhöht hat. Hieraus lässt sich darauf schliessen, dass eine Kreuzung gewissen Umfanges vor sich gegangen ist und der Chamazulengehalt dem intermediären Erbgang folgt. Ausserdem kann konstatiert werden, dass sich die Variationsbreite des Chamazulengehaltes in der zweiten Nachkommensgeneration des Versuches eingeengt hat. Diese Einengung betraf in annähernd gleichem Masse die extrem hohen und die extrem niedrigen Chamazulenwerte. Diese Ausgleichungstendenz der Mischpopulation kann nicht Jahreseffekten zugeschrieben werden, da in der gleichjährigen isolierten Vermehrung der Typenkomponenten eine ähnliche Tendenz nicht zur Geltung kam.

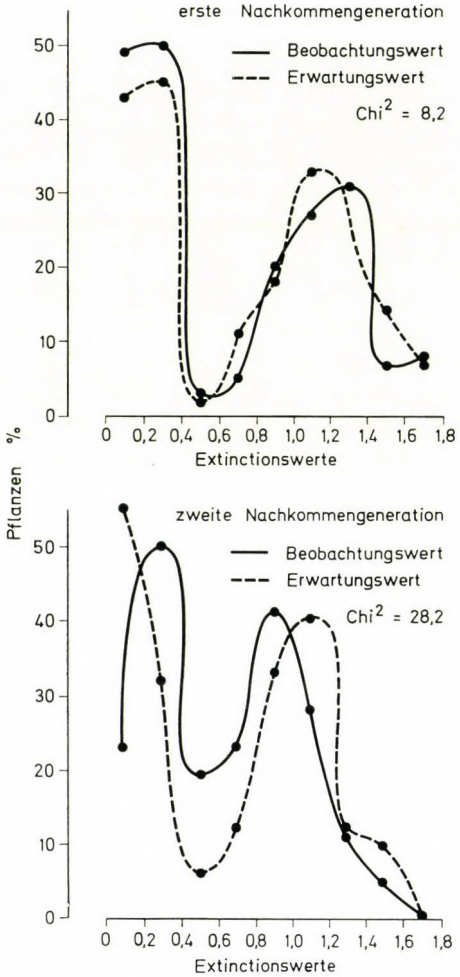

Abb. 1. Prozentuale Verteilung der Einzelpflanzen nach ihrem Chamazulengehalt in den erst- und zweitjährigen Nachkommensgenerationen der Modellmischsaat im Vergleich zu den summierten Erwartungswerten

Untersuchungen über die Möglichkeiten der Kamillentypenkreuzung in räumlicher Isolation

Die in den soeben beschriebenen Versuchen beobachtete Erhöhung des numerischen Anteils der intermädieren Typen gab uns den Anstoss, die Möglichkeiten einer Kreuzung der beiden abweichenden Typen in einem konkret hierauf abzielenden Versuch zu untersuchen. Zu diesem Zweck wurde der Versuch mit abwechselnder Reihensaat eingestellt, wodurch sich die Möglichkeit bot, die Einkreuzungsverhältnisse in der Nachkommensgeneration zu prüfen,

und zwar je nachdem ob die Prüfpflanzen fremden Pollen aus den unmittelbar anreihenden Nachbarreihen von beiden Seiten bzw. nur von einer Seite erhalten konnten oder ob sie dagegen durch je eine bzw. durch je zwei Reihen von Pflanzen des eigenen Typs geschützt waren.

Zur besseren Übersichtlichkeit wurden die Ergebnisse der Untersuchungsergebnisse an den Nachkommensgenerationen auf Grund der jeweiligen Extinktionswerte in 4 Gruppen geordnet. Die Untersuchungsergebnisse aus der 1. Nachkommensgeneration sind in Tabelle 4 zusammengefasst. Die Daten zeigen, dass die Einkreuzungsmöglichkeiten bei beiden Typen die gleichen waren, eine Kreuzung aber bei beiden nur dort erfolgte, wo sich die Pflanzen in unmittelbarer Nachbarschaft der Pflanzen des fremden Typs befanden. In der Nachkommensgeneration der durch eine bzw. durch je zwei Schutzreihen isolierten Pflanzenreihen zeigte die Verteilung der Einzelpflanzen nach dem Chamazulengehalt eine fast vollständige Übereinstimmung mit der Verteilung in den isolierten Ausgangspopulationen. Bei den mit dem fremden Typ unmittelbar benachbarten Reihen erhöhte sich demgegenüber die Zahl der Pflanzen mit den für den fremden Typ charakteristischen Chamazulen-Werten um 15—20%. Waren jedoch die Prüfpflanzen auch nur durch eine Isolierungsreihe gegen die fremde Pflanzenreihe abgeschirmt, so war überhaupt keine Einkreuzung nachzuweisen. Diese Beobachtung ist für die

Tabelle 4

Prozentuale Verteilung der Einzelpflanzen nach ihrem Chamazulengehalt in der F_1-Nachkommensgeneration der mit Isolation vermehrten Versuchsbestände

Extinktionswerte	Fremder Pollen				
	direkt		indirekt		Isolierte Vermehrung
	von einer Seite	von zwei Seiten	über eine Isolierreihe	über zwei Isolierreihen	
Typ I					
0,0—0,3	72	77	87	88	88
0,3—0,5	4	5	3	3	4
0,5—0,7	4	4	4	6	6
0,7	20	15	6	4	4
Typ II					
0,0—0,3	18	17	0	1	2
0,3—0,5	5	2	1	2	3
0,5—0,7	2	7	2	4	0
0,7	75	74	97	93	95
Gesamtzahl der geprüften Pflanzen	400	400	400	400	400

Erhaltungszüchtung von Bedeutung und bietet Richtlinien für die erforderliche räumliche Isolation.

Im weiteren Verlauf des Versuches wurde die Verteilung der Einzelpflanzen in den F_2 und F_3-Nachkommensgenerationen der hypothetischen Hybridpflanzen auf Grund der obenerwähnten 4 Gruppen der Extinktionswerte untersucht.

Von Typ I wurde aus den Samen der den Extinktionswert $<0{,}7$ ergebenden Pflanzen F_1-, und F_2- und F_3-Generationen entwickelt und deren Verteilung mit der Verteilung der aus der isolierten Vermehrung des Ausgangsmaterials erhaltenen Pflanzen verglichen. Die Ergebnisse sind in Tabelle 5 und in Abb. 2 zusammengefasst. Im Vergleich zum Ausgangsmaterial zeigte

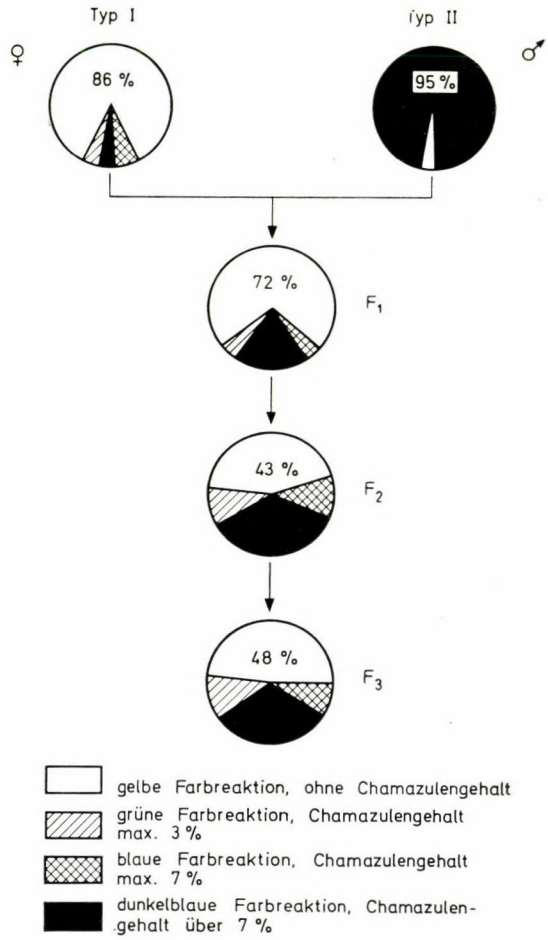

Abb. 2. Prozentuale Verteilung der aus der Samenernte von Typ I stammenden Hybridpflanzen nach ihrem Chamazulengehalt in den Nachkommensgenerationen F_1—F_3

Tabelle 5

Prozentuale Verteilung der aus der Samenernte von Typ I erhaltenen Hybridpflanzen nach ihrem Chamazulengehalt in den Nachkommensgenerationen F_1—F_3

Extinktionswerte	Häufigkeitsverteilung der Pflanzen in %			Isolierte Vermehrung von Typ I Durchschnitt von 3 Jahren
	F_1	F_2	F_3	
0,0—0,3	72	43	49	86
0,3—0,5	4	10	12	4
0,5—0,7	4	10	8	6
0,7	20	37	31	4
Gesamtzahl der geprüften Pflanzen	100	200	400	300

sich in den Nachkommensgenerationen der Hybridpflanzen eine erhebliche Erhöhung der Zahl jener Einzelpflanzen die blaue Farbreaktionen und einen Extinktionswert $<0{,}7$ ergeben.

Es scheint, dass die F_2- und F_3-Generationen bereits in eine Gleichgewichtslage kommen und dass diese im Vergleich zum Ausgangsmaterial eine wesentliche Verbesserung bedeutet. Der ursprünglich mehr als 80%ige Anteil der chamazulenarmen Pflanzen sank unter 50% ab, wogegen sich der Anteil der hochchamazulenhaltigen Pflanzen von der ursprünglichen einigen Prozenten auf über 30% erhöhte.

Anbauversuche auf Sodaboden mit der Kamillenzuchtsorte

Mit der grossblütigen Zuchtsorte Budakalászi 2 wurden mehrjährige Anbauversuche in der Gegend von Balmazújváros (ostungarisches Steppengebiet) auf umgebrochener Sodaweidefläche durchgeführt. Als erfreuliches Ergebnis konnte festgestellt werden, dass die grossblütige Sorte Budakalászi 2, die in Zuchtgartenvermehrungen Blütengewichte von 3,5—4,5 g aufweist, auch im Anbau auf Sodaboden eine relativ grossblütige Droge lieferte. Gegenüber den Blütengewicht von 1,5—2 g der aus Samen der örtlichen Wildpopulation stammenden Bestände, ergab die Sorte Budakalászi 2 auch auf dem Sodaboden Hundertblütengewichte von 2,8—3,2 g. Als günstiges Ergebnis konnte weiterhin verbucht werden, dass die künstlich getrocknete Blütendroge aus dem Anbau der grossblütigen Sorte Budakalászi 2 auf Sodaboden in mehrjähriger Lagerung nicht stärker auseinanderfiel und verstaubte, als die Blütendroge der kleinblütigen bodenständigen Wildpopulationen. Es bleibt jedoch fraglich, ob und inwieweit sich der züchterisch erzielte höhere Wirkstoffgehalt beim Anbau auf Sodaboden realisieren lässt, nachdem im Laufe des zweijährigen Versuchsanbaus gewisse Widersprüche auftauchten.

In einigen Fällen lieferte die Zuchtsorte im Anbau auf Sodaboden den erwarteten hohen Chamazulengehalt, vereinzelt kamen aber auch erheblich unter dem Erwartungswert liegende Gehaltswerte vor. Es wurde versucht, diesen Widerspruch auf populationsgenetischer Grundlage zu klären. Auf Zusammenhänge zwischen Umwelteffekt und genotypischer Zusammensetzung von Populationen hat übrigens auch STEIN (1965) schon hingewiesen.

Es kann angenommen werden, dass auf diesen uralten, natürlichen Kamillenfeldern im Boden verbliebene oder vom Wind angewehte Samen der bodenständigen Wildpopulation die Zuchtsorte verseucht haben und dass der durchschnittliche Wirkstoffgehalt der Sortenpopulation als Folge dieser genetischen Einmischung gesunken ist. Es handelt sich also wohl um eine durch Umweltbedingungen herbeigeführte, letzten Endes aber genetisch bedingte Veränderung.

Zur Überprüfung dieser Annahme wurde in Nachkommensgenerationen der auf Sodaboden angebauten Zuchtsorte Budakalászi 2 die Verteilung der Einzelpflanzen nach ihrem Chamazulengehalt in einer Gegenüberstellung von Ansaatkultur und Pflanzkultur untersucht. In der letzteren konnte nämlich die Einmischung der bodenständigen Wildpopulation ausgeschaltet werden.

In diesem Versuch wurden die Nachkommen der auf Sodaboden mit Anpflanzung aufgezogenen Zuchtsorte Budakalászi 2, die 17,4% Chamazulenwert zeigten, also scheinbar unvermischte Nachkommenschaft der Sorte darstellten (Stichprobe Nr. 3), mit Nachkommen derselben Sorte aus der Ansaatkultur verglichen, die 11,6% und 13,6% Chamazulengehalt aufwiesen (Stichproben 1 und 2); letztere zwei Stichproben repräsentierten also Bestände, in denen eine spontane Vermischung mit der bodenständigen Wildpopulation nicht ausgeschlossen war.

Die von diesen drei Stichproben erhaltenen Nachkommen wurden wieder auf Sodaboden angebaut, nun aber einheitlich in Pflanzkulturen, wobei das erhaltene Pflanzenmaterial wurde mit dem ursprünglichen, nicht von Sodaboden stammenden, isoliert vermehrten Basismaterial mit 18%igen Chamazulengehalt der Sorte Budakalászi 2 (Stichprobe 4 als Kontrolle) verglichen. Die Ergebnisse dieses Vergleichs sind in Tabelle 6 und Abb. 3 zusammengefasst.

Die prozentuale Verteilung der Nachkommenpflanzen der einzelnen Stichproben bestätigt ganz eindeutig die Stichhältigkeit der Annahme, dass im Falle der chamazulenarmen Stichproben 1 und 2 eine Vermischung der Zuchtsorte Budakalászi 2 mit der bodenständigen, chamazulenarmen Wildpopulation erfolgte. Bei Stichprobe 1 zeigt sich eine 30%ige, bei Stichprobe 2 eine 15%ige Fremdeinmischung im Bestand. Dieser Vermischungsanteil stimmt mit der Verringerung der Chamazulenwerte gegenüber dem Ausgangsmaterial gut überein. Bei Stichprobe 3, in dem zwar auf Sodaboden, jedoch in Pflanzenkultur vermehrten Bestand erfolgte keine Vermischung mit der Wildpopulation. Demgemäss zeigt dieser Bestand die gleiche Verteilung und an-

Tabelle 6

Prozentuale Verteilung der Einzelpflanzen nach ihrem Chamazulengehalt in den Nachkommensgenerationen der auf Sodaboden angebauten Zuchtsorte Budakalászi 2

Extinktionswerte	Stichproben aus den auf Sodaboden gewachsenen Beständen			Kontrolle 4
	1	2	3	
0,0—0,2	15	4	0	0
0,2—0,4	25	10	0	0
0,4—0,6	2	3	1	1
0,6—0,8	8	1	2	2
0,8—1,0	12	14	6	7
1,0—1,2	14	15	14	18
1,2—1,4	13	17	26	23
1,4—1,6	10	14	23	21
1,6—1,8	4	15	18	16
Gesamtzahl der geprüften Pflanzen	300	300	300	300
Chamazulengehalt der Stichproben in Prozenten des Gehalts an ätherischen Ölen	1 = 11,6	2 = 13.6	3 = 17,4	4 = 18,0

nähernd gleiche Chamazulenwerte, wie der auf sodafreiem Boden isoliert vermehrte Bestand der Sorte Budakalászi 2.

Die Ergebnisse dieses Versuches lassen die Annahme berechtigt erscheinen, dass die beim Anbau der hochchamazulenhaltigen Zuchtsorten auf Sodaboden zuweilen beobachteten verringerten Chamazulenwerte nicht dem Bodeneffekt zuzuschreiben sind, sondern durch Veränderung des genetischen Auf-

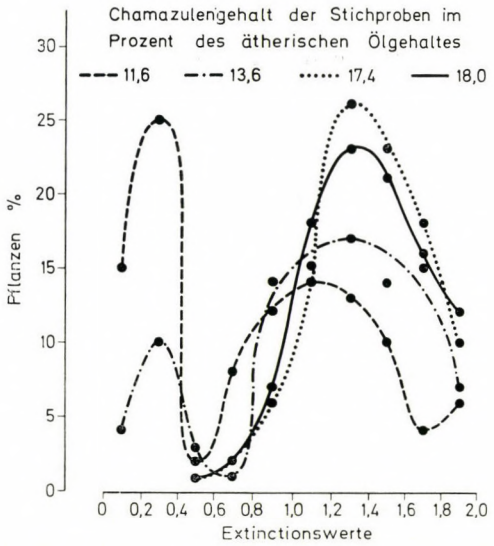

Abb. 3. Prozentuale Verteilung der Einzelpflanzen nach ihrem Chamazulengehalt in den Nachkommensgenerationen der Stichproben aus den auf Sodaboden gewachsenen Beständen der Zuchtsorte Budakalászi 2

baues der Populationen verursacht werden. Dies ist eine neuerliche Bekräftigung der Feststellung von KAISER—HASENMAIER (1965) und unserer eigenen Beobachtungen (SVÁB, 1967), dass nämlich die Höhe des Chamazulengehaltes in erster Reihe genetisch bedingt ist und von ökologischen Effekten kaum beeinflusst wird.

Die hier dargelegten Versuchsarbeiten sind bloss erste Schritte zur Klärung der theoretischen Grundlagen für die breitere Nutzung der in der ungarischen Kamillenzüchtung erzielten Ergebnisse. Unsere bisherigen Untersuchungsresultate deuten darauf hin, dass sich für die Steigerung des Chamazulengehaltes der ungarische Kamille verschiedene, auch theoretisch begründete Möglichkeiten bieten.

Zusammenfassung

1. Nachkommensgenerationen der Mischsaat einer kleinblütigen, wenig Chamazulen enthaltenden und einer grossblütigen hochchamazulenhaltigen Kamillentype blieb deren Verhältnis unverändert, und die Kreuzung der beiden Typen gestaltete sich je Jahrgang unterschiedlich.

2. Bei reihenweise wechselnder Nachbarsaat der kleinblütigen und grossblütigen Kamillentypen zeigte sich zwischen unmittelbar angrenzenden Reihen eine 15- bis 20%ige Einkreuzung.

3. Auf Grund der Versuchsergebnisse scheint die Kreuzung der beiden Typen durch Einschaltung von 1—2 Isolierreihen ausschliessbar zu sein.

4. In der Nachkommenschaft der Hybridpflanzen der beiden Typen kam die F_2-Population ins Gleichgewicht, das sich in der F_3-Generation schon stabilisierte.

5. Die beim Anbau der hochchamazulenhaltigen Zuchtsorten auf Sodaboden zuweilen beobachtete Verringerung des Wirkstoffgehaltes ist der Verseuchung durch die bodenständige Wildpopulation zuzuschreiben. In reinen Linien kam kein chamazulenverringernder Effekt des Sodabodens zur Geltung.

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NET PRECIPITATION IN A HUNGARIAN OAK FOREST ECOSYSTEM*

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The paper joins to the complex ecosystem research into the climate-zonal oak forest *(Quercetum petraeae-cerris)* of the hilly region between the Transdanubian Central Mountains and the Great Plain. It examines the precipitation quantities in 1974, by sampling fortnightly, which arrive above the forest canopy, and those which fall through the tree and shrub layer and flow down on the trunk of trees, reaching the forest soil.

The throughfall beneath the oak canopy was collected by using 14 polyester troughs of 20×100 cm collecting surface, while the stemflow by the aid of 14 polyurethane collars placed around the trunks.

The study determines the interception, its seasonal changes, and analyzes the differences between the two tree species and between the tree and shrub combinations. The data are also calculated for hectare.

Among the processes taking place in the ecosystem, the pattern of water circulation is decisive from several viewpoints. For example, to follow the quantitative and qualitative course of productivity, or to explore the bio-element cycles, and to understand the whole ecosystem balance itself, the knowledge of water circulation pattern in time and space is indispensable. Since however water circulation itself is a very complicated and complex process, investigation into it may be facilitated if the informative data are obtained separately from the individual sections of the process which may be combined later. Sections of the ecosystem water circulation may be composed of elements like: input water; pathway of water, reaching the ecosystem in the form of precipitation, to the soil; water in the soil; water used and stored by living organisms; output water (with two of its branches: through organic and through inorganic matter).

The purpose of the present paper is to describe one of these sections — the dynamics of the precipitation falling onto the soil — in relation to the water circulation of a forest ecosystem examined over one year. Our examinations are part of the complex ecosystem research ("Síkfőkút Project", cf. JAKUCS 1973), taking place within the framework of the MAB program, on the model area allocated in the Pannonicum climate — zonal oak forest.

* "Síkfőkút Project", No. 14.

The quantities and way of the precipitation falling to the forest floor have already been studied for a long time. By a random selection we refer, for example, to the investigations of ZINKE (1967) carried out in the USA who published a summary. In the most important forest types of Great Britain, OVINGTON (1954), REYNOLDS—LEYTON (1963), RUTTER (1963), CARLISLE—BROWN—WHITE (1965), REYNOLDS—HENDERSON (1967) and LEYTON—REYNOLDS—THOMPSON (1967) made similar investigations. The works of DELFS (1967) and ULRICH (1971) in the beech and spruce stands of Central Germany; as well as the precipitation investigations in the Mediterranean oak forests by ETTEHAD—LOSSAINT—RAPP (1973) should also be mentioned. MOLCHANOV (1971) reported on the water budget of the zonal forests in the Soviet Union. INTRIBUS (1970) gives a preliminary report on the investigation that have been started in a Slovakian blue hornbeam-oak forest.

Site and method

Our examinations were carried out in a 65 year old homogeneous, offshoot originated turkey oak forest *(Quercetum petraeae-cerris)* in the hill-country lying in the interception of the Northern Mountains and the Great Plain. In the canopy layer *Quercus petraea* (84%) is dominant, beside it, *Quercus cerris* (16%). The crown canopy is 80 per cent closed, the average tree height is 17.3 m, the mean trunk diameter is 20 cm, and there are 816 trees per hectare. The shrub stratum of the forest is also very rich, its average coverage is 66% (JAKUCS—HORVÁTH—KÁRÁSZ, 1974). The annual precipitation of the area is 540—580 mm as an average of 50 yeras; in the year of examination it was 710 mm. The yearly mean temperature is 9.9°C; the same in the growing season is 17°C.

The experiments were carried out on a 50×50 m (a quarter of a hectare) area allocated for this purpose ("Síkfőkút Project", "B" square). Incident rainfall (a), throughfall (b) and stemflow (c) were measured. The examinations were carried out from 27 February, 1974, to 4 December, 1974. The foliage of the forest was fully developed by the middle of May, and the great majority of the foliage fell down by the end of October. The collecting buckets were emptied once a week, a fortnight, and possibly more rarely, correspondingly with the rainfalls, altogether on 23 occasions. Evaporation loss with the black-colour collecting buckets is negligible, according to our measurements. It should be mentioned here that the only water source of the forest examined is the atmospheric precipitation, which, in the vegetation period, is realized exclusively in the form of rainfalls (in summer these are heavy rainfalls). The quantity of moisture precipitating by dew is small in the forest; more considerable are the quantities of water precipitating

from fog, these however — similar to snow — are characteristic of the winter months.

(a) Measurement of the incident rainfall was carried out on the top of a 24 m high tower erected on the area, at a height of 4 m above the forest canopy, in a polyester collecting trough of 2000 cm^2 surface area, similar to throughfall. On the same place, on top of the tower, HELLMANN-type rain gauges were also put out. A comparison between the quantities of the precipitation measured with the two methods raises methodological problems. The control input precipitation is in general measured in open land near by the forest examined and this is adapted to the forest (CARLISLE—BROWN—WHITE, 1965; SKAU 1964; MAYER 1971, etc.). In the middle of our examination year we also put out rain gauges on the open land farther from the forest edge, whereby obtaining comparative data relating also to the atmospheric precipitation quantities measured at the two places.

(b) The throughfall was collected in the 14 troughs of 2000 cm^2 collecting surface each placed on a quarter of hectare, of which the water was gathered in plastic buckets (Fig. 1). The CV of the data obtained in this case is around 10%, except for the water quantities measured in the case of low incident rainfall, when the CV value of the data amounts to even 20—30%. The error of the data, on the basis of the BARTLETT-test proved to be homogeneous. The

Fig. 1. Throughfall collecting trough (surface area 2000 cm^2) (Photo: M. Szabó)

collecting troughs were placed out according to the following combination: 5 under the canopy of *Quercus petraea*, 3 under *Qu. cerris* tree, 3 under *Qu. petraea* tree + *Acer campestre* shrub, and 3 under *Qu. petraea* tree + *Cornus mas* shrub.

(c) The stemflow was measured also in the allocated area, on 14 trees whose dbh. was near the mean stem diameter. Polyurethane collars were placed at a height of 130 cm on the stem of 9 *Quercus petraea* and 5 *Quercus cerris*, and the stemflow was collected in plastic cans (Fig. 2). The possibility

Fig. 2. Stemflow collecting equipment. The drain tube is led into a 50 l plastic bucket (Photo: L. Nagy)

of applying polyurethane foam for catching stemflow water was reported by LIKENS—EATON (1970).

(d) The relations between the incident rainfall and the throughfall and stemflow quantities were evaluated on the ODRA 1024-type computer of the Kossuth Lajos University, Debrecen.

Results

The atmospheric precipitation in forest ecosystems never reaches the soil in full quantity. The water quantity which finally gets down to the soil can be divided into two parts. One part falls directly through the canopy, or it gets to the soil by dripping down from the leaves (i.e. canopy drip), this is the so-called throughfall. The other part flows down along the branches and trunks and reaches the soil in this way; this is the stemflow. The difference between the water-quantity reaching the canopy and that getting finally onto the soil, is the interception loss. The maximum water-quantity which can physically be retained by the vegetation is called the canopy storage capacity. This, together with that part of the water which evaporates during the rainfall give the maximally possible interception loss.

(a) *Throughfall*

The quantity of throughfall as a function of incident rainfall examined in four variations can be expressed by a linear regression curve (Fig. 3). Accordingly, the largest quantity of precipitation arrived through the canopy of *Quercus cerris* to the soil, while the least through the foliage of *Quercus petraea*. Interestingly, in the case of shrub combinations more water reached the soil than through the foliage of *Quercus petraea*. This is explained by the fact that in the forest above the shrubs the canopy is in general — and in our sampling case it was so — less closed. The quantities of the throughfall of the two shrub species are nearly identical with each other, therefore, the regression curve is given only for *Quercus petraea* + *Cornus mas*. The greater quantity of water arriving through the foliage of Turkey oak to the soil probably comes about from the particular canopy pattern of the species and from the small values of its canopy storage capacity. We calculated these values by extrapolating the regression curves, and considered them only as of an informative character since their more accurate determination would require measurements by the rainfall. We remark, in addition, that the correlation between throughfall and atmospheric precipitation in the case of a small quantity of rain is not linear.

Since the regression equations were calculated for water quantities collected on a 2000 cm^2 surface, the results should be divided by 200 when

calculating for mm units. Thus the regression curves will give the following results:

Quercus petraea $T = 0.738\ P - 0.557$ $r = 0.994^{***}$
canopy saturation: 0.75 mm
Quercus cerris $T = 0.858\ P - 0.354$ $r = 0.995^{***}$
canopy saturation: 0.42 mm
Quercus petraea + *Acer campestre* $T = 0.799\ P - 1.476$ $r = 0.989^{***}$
canopy saturation: 1.84 mm
Quercus petraea + *Cornus mas* $T = 0.786\ P - 0.858$ $r = 0.990^{***}$
canopy saturation: 1.09 mm
Total throughfall $T = 0.805\ P - 0.966$ $r = 0.993^{***}$
canopy saturation: 1.20 mm
T = throughfall (mm); P = rainfall (mm);
Significance of the correlation coefficient r^{***}: P = 0.1%

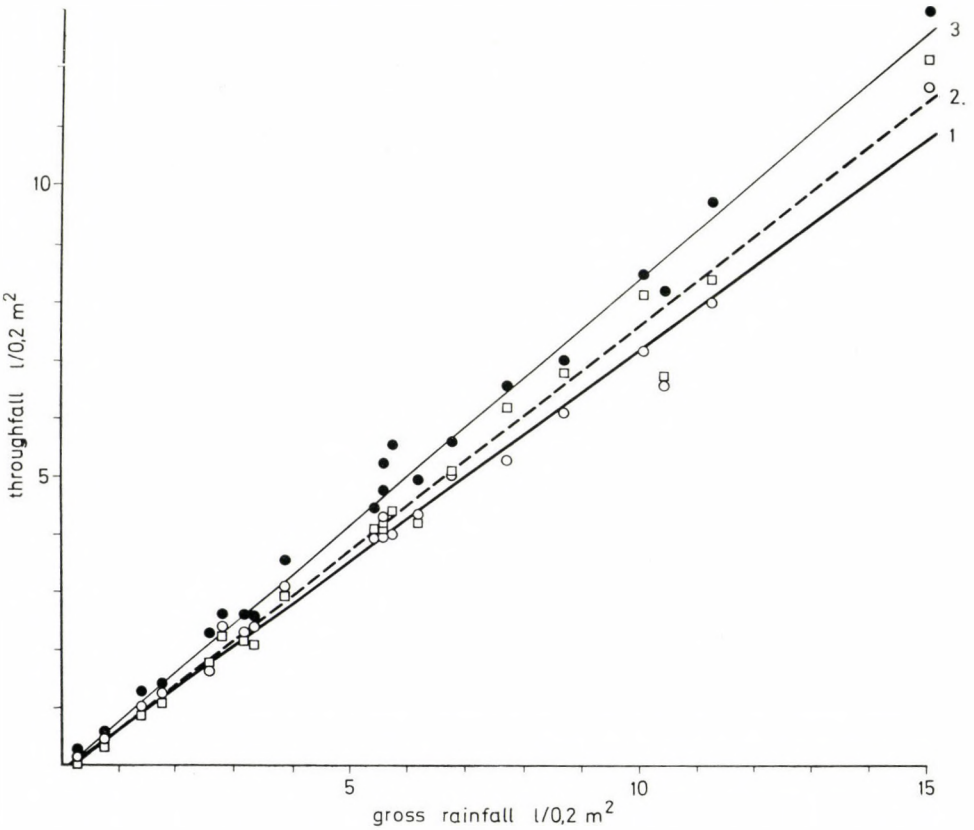

Fig. 3. Linear regression of throughfall on gross precipitation. 1. *Quercus petraea* T = 0.738P — — 11.395, r = 0.994***; 2. *Quercus petraea* + *Cornus mas* T = 0.786P — 171.638, r = 0.990***; 3. *Quercus cerris* T = 0.858P—70.752, r = 0.995***; T = throughfall; P = gross rainfall

The canopy storage capacity values vary according to species, and they depend to a considerable degree on the leaf surface index, the leaf tissue construction, and on the changes in weather conditions varying according to seasons.

ZINKE (1967) recorded 0.25—9.15 mm canopy storage capacity values in general; his values are higher in conifers than in deciduous species. The values of the latter in the leafless period are evidently smaller than in the vegetation

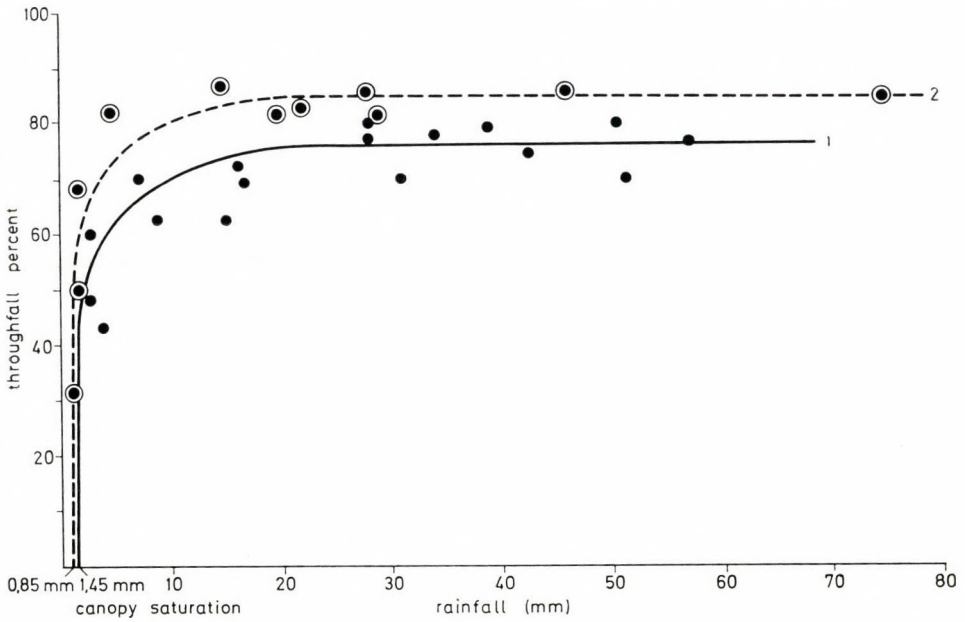

Fig. 4. The relationship between throughfall and gross rainfall. Throughfall is expressed as a percentage of rainfall. 1. Leafy season; 2. leafless period

period. LEYTON—REYNOLDS—THOMPSON (1967) obtained smaller values with hornbeam in winter, but higher canopy storage capacity values for beeches in winter. According to our examinations, the canopy storage capacity value of *Quercus petraea* in the leafy period is 0.9 mm, while in the leafless period 0.60 mm.* The throughfall quantities in mm and in the percentage of the atmospheric precipitation, are given in Tables 1 and 2, and in Fig. 4. It is conspicuous in this figure, where the throughfall has been demonstrated for the vegetative and for the leafless periods, in the percentage of precipitation, that the canopy storage capacity value in the vegetation period is 1.45 mm. The

* RUTTER (1963) determined the canopy storage capacity value in vitro, with artificial moistening, and his value was smaller than those calculated by extrapolation.

Table 1

Interception of rainfall

Day of sampling	Gross rainfall	Throughfall		Stemflow		Total on soil**		Interception	
	mm	mm	%	mm	%	mm	%	mm	%
13. Mar.	4.3	3.6	83.3	0.1	0.7	3.7	84.0	0.7	17.0
10. Apr.	1.8	0.9	50.0	0	0	0.9	50.0	0.9	50.0
24. Apr.	1.5	0.5	33.3	0	0	0.5	33.3	1.0	66.7
3. May	28.5	23.2	81.5	0.9	2.9	24.1	84.4	4.4	15.4
8. May	19.4	16.1	83.3	0.7	3.6	16.8	86.9	2.6	13.1
22. May	30.8	21.6	70.0	0.7	2.2	22.2	72.2	8.6	27.8
5. Jun.	33.8	26.3	77.9	0.6	1.7	26.9	79.6	6.9	20.4
12. Jun.	43.0	32.4	75.4	1.6	3.6	34.0	79.0	9.0	21.0
19. Jun.	27.8	22.3	80.3	0.8	2.9	23.1	83.2	4.7	16.8
26. Jun.	2.5	1.2	48.0	0	0	1.2	48.0	1.3	52.0
3. July	14.8	9.4	63.2	0.6	4.6	10.0	67.8	4.8	32.2
17. July	7.0	5.0	71.4	0.1	1.4	5.1	72.8	1.9	27.2
31. July	16.0	11.5	72.0	0.2	1.1	11.7	73.1	4.3	26.9
21. Aug.	51.7	35.1	67.9	0.9	1.7	36.0	69.6	15.7	30.4
29. Aug.	38.4	29.8	77.6	1.6	4.2	31.4	81.8	7.4	18.2
6. Sept.	16.5	11.4	69.4	0.4	2.1	11.8	71.5	4.7	28.5
25. Sept.	27.7	21.4	77.5	1.0	3.3	22.4	80.8	5.3	19.2
2. Oct.	8.7	5.9	67.3	0.1	1.1	6.0	70.0	2.7	30.0
9. Oct.	50.0	39.8	79.7	2.0*	3.9*	41.9	83.6	8.2	16.4
17. Oct.	55.7	43.6	78.3	2.0*	3.5*	45.6	81.8	10.1	18.2
23. Oct.	74.3	61.9	83.3	2.0*	2.7*	63.9	86.0	10.4	14.0
30. Oct.	14.0	12.2	87.1	0.6	4.3	12.8	91.4	1.2	8.6
4. Dec.	27.1	23.3	85.8	1.5	5.5	24.8	91.5	2.3	8.5

* Stemflow values are underestimated, since many containers overflowed
** Sum of throughfall and stemflow (net rainfall under forest canopy)

throughfall percentage above 25 mm atmospheric precipitation is practically constant (75—80%). The throughfall average for the vegetation period is 75.9%. In the leafless period, the canopy storage capacity value is smaller (0.85 mm). In this period the throughfall percentage becomes constant already above 10 mm precipitation and is between 80—87%. In the leafless period the average throughfall is 82%.

Table 2

Distribution of rainfall within the forest ecosystem

Rainfall,	Throughfall		Stemflow		Total on soil		Interception	
mm	mm	%	mm	%	mm	%	mm	%
Vegetative period (8. V.—23. X.)								
498.7	378.2	75.9	14.6	2.9	392.8	78.8	105.9	21.2
Leafless period								
96.6	78.4	81.2	3.8	3.9	82.2	85.1	14.4	14.9
Year (27. Febr.—4. Dec. 1974)								
595.3	456.6	76.8	18.4	3.1	475.0	79.9	120.3	20.1

(b) *Stemflow*

Expressed in a projection of the canopy or the whole forest surface, stemflow amounts only to a small portion of the precipitation arriving to the soil. But if we consider that in reality the stemflow courses down concentrated onto the soil surface around the stem, it is easy to realize its importance in increasing the moisture content of the soil, and through this, in the water budget of the forest. This role is emphasized among others by VOIGT (1960), REYNOLDS—LEYTON (1963), and ESCHNER (1967), too.

There are many authors who neglect the examination of stemflow, partly owing to its insignificant quantity, and partly because of some difficulties in measuring. The quantity of stemflow is very variable. We also obtained rather high CV values (20—70%) in the course of our measurements, and they did not decrease below 20% even in the case of heavy incident rainfall.

This may be due to the fact that the branching form, and formation of the bark, in the trees marked is different, the distance relation of their canopy to the foliage of the surrounding trees is different, and their stem diameter and so their bark surface is not entirely uniform either. In our case, these may become such substantial factors that can to a great extent influence the quantity of stemflow.

The canopy of the 14 trees examined covers altogether 163 m^2 in the area 9 *Quercus petraea* 100 m^2, 5 *Quercus cerris* 63 m^2. Thus, we examined the quantity of the stemflow of trees belonging to the 163 m^2 canopy area. For the purposes of a comparison between the stemflow and throughfall, the stemflow for 2000 cm^2 or one hectare was also calculated. The linear regression

equation for stemflow was also calculated (Fig. 5). From the regression curves it seems that more precipitation arrives to the soil on the stem of Turkey oak than on that of *Quercus petraea*. The cause of this may be found in the differing branching in the two species and in the difference of bark construction. The bark of *Quercus petraea* is strongly squamosous, stratified, thus the soaking value of the bark is assumably high. On the other hand, the bark of *Quercus cerris* is hard, and water quickly runs down on it (see later). The quantity of stemflow is considerable mainly at heavy rainfalls, and in the leafless period of the forest (see Tables 1 and 2, where the quantity of stemflow is expressed in mm, and in the percentage of the atmospheric precipitation). Since our measurements were carried out not after the individual rainfalls, the concrete effect of the duration, quantity and intensity of the rainfall on the quantity of stemflow is not known.

By the extrapolation of the regression curves the quantity of the rainfall above which the stemflow commences can be determined here too.

Quercus petraea $S = 0.037\ P - 0.203$ $r = 0.991^{***}$
threshold value: 5.5 mm

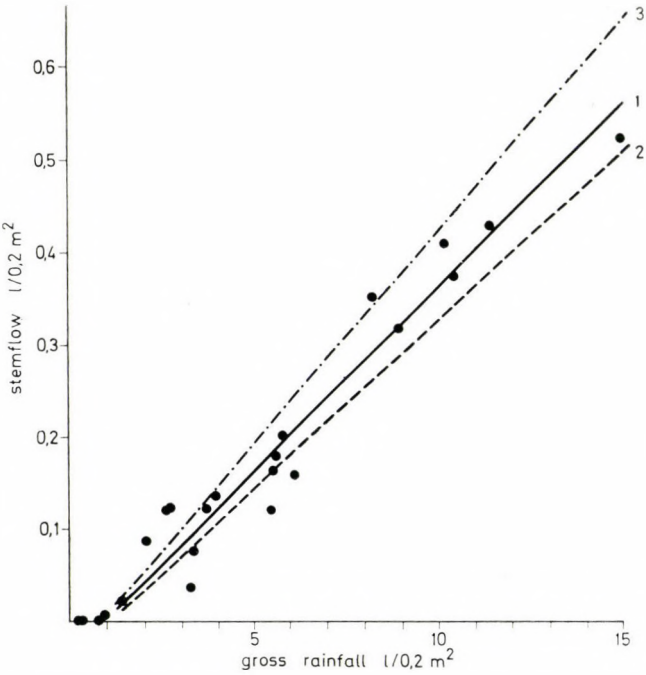

Fig. 5. Linear regression of stemflow on gross precipitation. 1. Total stemflow $S = 0.042P - -1.602$, $r = 0.905^{***}$; 2. *Quercus petraea* $S = 0.037P - 40.632$, $r = 0.911^{***}$; 3. *Quercus cerris* $S = 0.052P - 46.152$, $r = 0.891^{***}$; S = stemflow; P = gross rainfall

Quercus cerris $S = 0.052\ P - 0.230$ $r = 0.891^{***}$
threshold value: 4.4 mm
Total stemflow $S = 0.042\ P - 0.208$ $r = 0.905^{***}$
threshold value (quantity of precipitation above which stemflow commences): 5.0 mm
S = stemflow (mm): P = rainfall (mm);
significance of the correlation coefficient r^{***} P = 0.1%

It can be inferred therefore that in the forest ecosystem examined the vegetation intercepts the whole rainfall below 1.2 mm, and thus water does not arrive to the soil. The rainfall between 1.2 and 5.0 mm reaches the soil of the forest only as throughfall.

In *Juniperus* species SKAU (1964) determines the threshold value of stemflow to be 5—8 mm precipitation, while in Mediterranean oaks LOSSAINT—ETTEHAD—RAPP (1973) record it to be 10—12 mm. DELFS (1967) determines it at 2 mm in beeches, in Delfs the stemflow amounts as an average to some 15% of the precipitation. MAYER (1971) measured 8% stemflow also in a beech stand. OVINGTON (1954) carried out investigations in *Quercus petraea* forests, and the stemflow amounted to only 0.28% of the precipitation. We consider this too low, for on the basis of our own measurements, in the case of about the same quantity of yearly precipitation the stemflow varies between 0—5.5%: in the vegetation period it is 2.9%, in the leafless period 3.9, and in the whole examinational period the average is 3.1%.

(c) *Interception loss*

"Interception loss: the part of the precipitation retained by the aerial part of the vegetation, and is either absorbed by it or is returned to the atmosphere by evaporation" — HAMILTON and ROWE (in ZINKE, 1967). Interception loss is therefore twofold. One side, the so-called canopy storage capacity has already been dealt with above; the other is the evaporation loss during the rainfall, which always depends on the actual conditions. On the one hand, the water retained in the ecosystem cannot be considered as loss totally; the water which has evaporated from the surface of plants remains in the atmosphere of the forest, increasing its relative humidity content. On the other hand, evaporation is associated with heat extraction, this reduces the temperature of the forest, which indirectly entails an increase in the relative humidity content of the air. STONE (1957) indicates that moisture absorption on leaves has since long been known and calls this "negative transpiration". In relation to the soil-vegetation, the absorbed water cannot be considered as a loss either, since it counteracts to a great extent the loss in soil moisture content which would otherwise be caused by the increased transpiration.

The quantity of the intercepted water, expressed in mm and also in the percentage of the incident rainfall in the stand examined by us is shown according to samples, in Table 1, while its seasonal changes and yearly totals are given in Table 2.

The results show that in the case of small quantities of precipitation, interception can reach even 50—66%, while in greater rainfalls it varies between 16 and 30%, depending on the quantity, the duration and intensity of the precipitation. The concrete determination of these factors forms part of our further examinations.

The interception of the rainfall by our forest was 20.1% of the incident rainfall per annum. In the vegetative period interception was 21.2% and during the leafless period 14.9%.*

In *Quercus petraea* forest, OVINGTON (1954) measured 34% interception in the case of 840 mm annual rainfall, whereas CARLISLE—BROWN—WHITE (1965) report only 13.1% with a high average annual rainfall (1714 mm). According to several authors (BEALL, 1934; TRIMBLE—WEITZMANN, 1954; DELFS, 1967) interception does not decrease, or decrease only to a small extent, with defoliation.

(d) *Water-balance of the ecosystem***

On the basis of our measurements we can give for 1974 (from February 27 to December 4) the quantity of precipitation which reaches the soil of the forest from the quantity falling on to a forest area of one hectare; the way of rainwater and the quantity of water intercepted by the forest. All of these have been calculated in the knowledge of canopy coverage. The forest examined is not entirely closed, foliage is of 80%, larger, canopy holes are frequent; where the precipitation can reach the forest soil surface almost directly (naturally through the herb layer and litter).

The measurement results are given in Fig. 6 where the percentage distribution of the incident rainfall in a forest of one hectare is given, while above the diagrams the mm values corresponding to the quantity of incident rainfalls. In accordance with the canopy-closure (80 per cent) we considered 20 per cent openings where the whole amount of rain can reach the forest soil at each time of sampling and we indicated the distribution of only the remaining 80 per cent.

* We consider the 14.9% interception too high; it might be due to the very small quantity of precipitation that fell in April, a considerable portion of which was intercepted by the forest.

** The mm and percentage values given in Tables 1 and 2 have been calculated on the basis of the water collected from the 2000 cm^2 area, from such surface of the forest where the canopy is entirely closed. When calculating the water balance of the stand, on the other hand, we considered only 80% as in covered state in the case of both throughfall and stemflow.

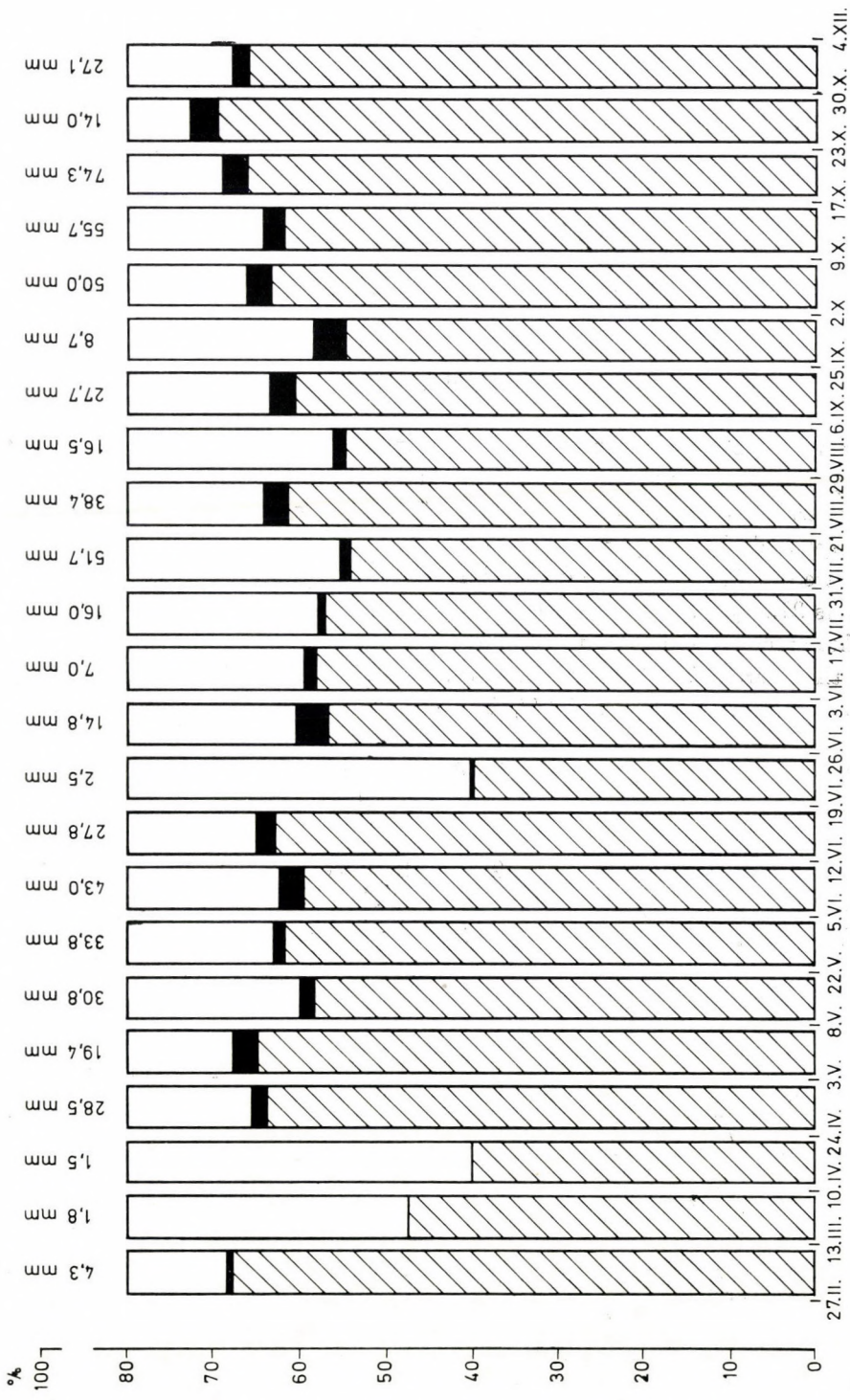

Fig. 6. Distribution of precipitation falling on 1 hectare forest

In a yearly total, the distribution of the precipitation of 5.953×10^6 litre arriving at one hectare is as follows:

Throughfall	3.641×10^6 litre	(= 61.2%)
Stemflow	1.472×10^5 litre	(= 2.5%)

Amount of the rain is driven across the openings on the soil

	1.19×10^6 litre	(= 20%)
Intercepted water:	0.97×10^6 litre	(= 16.3%)

Summary

In the framework of the MAB program in Hungary, we examined the pathway of rainfall to the soil and its distribution in 1974, for *Quercetum petraeae-cerris* ecosystem within the "Síkfőkút Project". We established that the foliage and shrub layers of the ecosystem intercept 20.1% of the rainfall in the case of a 595.3 mm incident rainfall. In the vegetative period the interception is 21.2%. With defoliation, interception decreases, when it is 14.9%.

The amount of throughfall water in the whole period of the examination was on the average 76.8%, in the vegetative (leafy) period 75.9%, while in the leafless period of the forest 81.2%. The quantity of throughfall is influenced also by the tree species.

The canopy storage capacity also depends on the tree species, and on the seasons as well. In the vegetative period it is 1.45 mm, in the leafless state it is 0.85 mm.

Stemflow on the average is 2.9% in the vegetation period, 3.9% in the leafless period and 3.1% in the whole year of examination. Stemflow commenced only when rainfall was above 5 mm.

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A STUDY OF FLOODING EFFECT ON MAIZE TRANSPIRATION AT TWO NUTRIENT LEVELS

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The author examined the effect of flooding on maize transpiration and found that the excess water caused root decay and wilting which greatly decreased the transpiration rate. Flooding had a much greater effect on the decrease of transpiration rate in the fertilized treatment than in the unfertilized one.

Introduction

Water, depending on its amount effects the transpiration of maize plants in soil in three ways: (1) Insufficient water limits (SZLOVÁK, 1972; SZLOVÁK, 1973), (2) optimal water supply ensures normal transpiration. (3) Excess water, similarly to insufficient water though in an other way (by limiting the normal metabolic activities) also influences for a short time the transpiration rate negatively. Excess water exerts its harmful effect not directly, but indirectly, by bringing about anaerobic environment. That is why plants can develop well in aerated water cultures (KRAMER, 1940; CHANG and LOOMIS, 1945).

There is an essential difference among different plant species regarding the minimum soil air at which they can thrive. According to BELÁK (PETRASOVITS and BALOGH 1969) the minimum soil air requirement of the maize plant is 24% of the soil pore space. KNOP (ANDREJENKO and KUPERMAN, 1961) reported that a maize plant respires 0.25 g carbon dioxide during 24 hours, corresponding to 0.18 g of O_2 taken up by the plant.

Poor aeration causes carbon dioxide accumulation, oxygen deficiency and the production of toxic substances. HAGAN (1950) found that carbon dioxide reduces permeability of roots to water. By saturating with carbon dioxide the soil or the water in which sunflower and tomato plants were growing, KRAMER (1940) observed a transpiration reduction of 34 to 52%. The experimental results of FOX (1933) indicate that carbon dioxide increased the viscosity of the protoplasm of *Nitella*, thus increasing the reduction of permeability. KRAMER (1949) explains the harmful effect of oxigen deficiency on water absorption by the reduction in rate of aerobic respiration and by accumulation of incompletely oxidized toxic products of anaerobic respiration.

Since permeability is closely related to metabolism this disturbance of normal metabolism may result in changes in permeability and finally in death of the root cells. Inadequate aeration limits not only the active water absorption, but according to the results of KRAMER and JACKSON (1954) the passive water movement through the roots is also reduced.

The flooding effect was studied in Hungary mainly in relation to plant surviving (GRUBER and SZALÓKI, 1963; SZALÓKI, 1967) and yield reduction (PETRASOVITS, 1959).

So far I have not met with any publication dealing with the effect of flooding on maize transpiration at different nutrient levels, thus it seemed necessary to examine the water relations of maize plant in this respect too. The main purpose of this paper is to give information about the effectiveness of nutrients in altering maize transpiration under flooded conditions.

Material and method

On 30 April, 1973, maize seeds were planted in pots in a growth-house. The plants were exposed to environmental factors nearly identical with those in the field, namely the culture pots containing the plants were placed on carts running on a track and moved every morning into a space enclosed by a wire net. For the night and when it rained the carts were pushed under a glass roof.

In the 20×25 cm white enamel painted pots for 4 kg absolute dry soil, air dry alluvial-meadow surface soil (Szarvas-Bikazug) was placed. The maximum waterholding capacity of the soil was determined in laboratory and a value of 50.10% was obtained (expressed in weight % of absolute dry soil). The soil on which the Mv-620 hybrid maize plants developed was filled to 70% of its maximum waterholding capacity at daily waterings.

The effect of flooding upon transpiration was studied in fertilized and unfertilized treatments. The active ingredients of fertilizers per pot in the fertilized treatment were as follows: N : 1.6 g (ammoniumnitrate), P_2O_5: 0.8 g (superphosphate), K_2O: 0.8 g (Potash, KCl). The fertilizers were mixed thoroughly with soil and placed in the pots. In the unfertilized treatment the plants had to rely on the nutrients present in the soil.

Five seeds were sown per pot. After emergence the plants were thinned to one in each pot.

Up to the flooding date (16 July) all plants developed at the optimum soil moisture. During flooding there was a 6 cm thick water layer above the pot soil. To eliminate water evaporation and water airing 5 mm thick sunflower oil was layered on the water.

On the 6-day examination the transpiration values presented are the average values calculated per hour of the total transpiration between 7 a.m. and 7 p.m. On the day following the last daily transpiration measurements (26 July) the plants were harvested for the transpiration intensity calculations. Transpiration measurements were done in 5 replicates.

The plants were flooded at 4 p.m. on 16 July. On the next day the transpiration values presented were obtained by deviding the total amount of transpiration between 7 a.m. and 7 p.m. by twelve, the hours of investigation. This means that during this time the plants were flooded for a period between 12 and 24 hours. On all of the six daytime investigations the average of the 12-hour transpiration was used in calculations. The cumulative transpiration values represent the total transpiration during the whole, 24-hour, days of investigation. For transpiration measurements of the unflooded plants the pot soil was covered by PVC film. Thus the water loss of pots was due solely to the transpiration by plants.

The amount of transpired water was restored by daily waterings.

The solar radiation data were obtained from the Station of the National Meteorological Institute situated at a distance of about 500 metres from the growth-house.

Results

In the unflooded treatments both the unfertilized and fertilized plants showed a decreased transpiration rate as the days of investigation advanced (Table 1). This decrease is due to the change of meteorological factors influencing transpiration. Thus, while on 18 July the value of one of the most important meteorological factors, the solar radiation was 630.50 cal. $cm^{-2} \cdot day^{-1}$, on 25 July this value dropped to 480.80 cal $cm^{-2} \cdot day^{-1}$.

From Table 1 it can be seen that in the unflooded treatment the fertilized plants transpired more than the unfertilized ones. This is expected, since the plants supplied with nutrients were better developed than those receiving no fertilizers. If the transpiration of unfertilized plants is examined in per cent of the fertilized ones, in unflooded treatment, it can be seen that the percentage difference is decreasing between 18 July and 25 July. This per cent decrease can be explained by the faster growth rate of fertilized plants, making possible the development of a larger transpiring leaf area. If the transpiration rate of plants with different nutrient supplies is examined under flooded conditions, the change in the per cent transpiration ratio is opposite to that seen above. That is, while on the second day of flooding the per cent transpiration of the unfertilized plants was 41.70 of the fertilized plants, on the eight day of flooding this ratio rose to 64.79%. This means that the flooding decreased the transpiration of the fertilized, better developed plants to a greater degree than that of the unfertilized, less developed plants.

While on 18 July the per cent transpiration ratios of both unfertilized and fertilized plants in the flooded treatment related to the unflooded treatment were similar (87.14 and 91.98%), on 25 July the transpiration of unfertilized plants sank to 25.09% and that of the fertilized plants to 4.23%. The results show that the transpiration rate of the fertilized plants with more intensive life processes was more limited by the unfavourable conditions resulting from flooding than the transpiration rate of the unfertilized, less intensively growing plants.

Transpiration intensity data, calculated per unit dry matter, are presented in Table 2. They are the average values calculated per hour of the daytime transpiration of plants being flooded for a period of between 204 and 216 hours. The obtained data indicate that a transpiration rate calculated not only per a whole plant, but also per a unit dry matter is similar under differently aerated and fertilized treatments.

According to the dry weight of plants harvested on 26 July and shown in Table 3, the difference between the unflooded and flooded treatments of unfertilized plants is quite small. The greatest difference is observed at the roots. The lower root weight of the flooded plants can be explained by root decay. In the fertilized treatment, the flooding caused a pronounced dry matter

Table 1

Effect of flooding on the transpiration rate ($g \cdot hour^{-1}$) of unfertilized and fertilized maize plants in the daytime hours

Days in July	Unflooded transpiration		Flooded transpiration		Transpiration of unfertilized plants in % of the fertilized ones		Transpiration of flooded plants in % of the unflooded ones		Duration of flooding in hours
	unfertilized	fertilized	unfertilized	fertilized	unflooded	flooded	unfertilized	fertilized	
17.	26.00 ± 3.57		24.83 ± 1.52				95.50		12— 24
18.	23.33 ± 2.78	53.00 ± 2.11	20.33 ± 2.11	48.75 ± 11.64	44.02	41.70	87.14	91.98	36— 48
19.	16.66 ± 2.55	47.92 ± 2.89	11.58 ± 1.48	24.33 ± 4.71	34.77	47.60	69.51	50.77	60— 72
21.	17.83 ± 3.66	51.50 ± 3.30	10.58 ± 2.03	4.83 ± 1.40	34.62	45.65	59.34	9.38	108—120
23.	9.83 ± 2.09	38.00 ± 5.30	3.92 ± 2.09	2.50 ± 1.02	25.87	63.77	39.88	6.58	156—168
25.	5.66 ± 1.18	21.75 ± 2.86	1.42 ± 1.00	0.92 ± 0.75	26.02	64.79	25.09	4.23	204—216

Table 2

Transpiration intensity ($g \cdot hour^{-1}$) of maize plants of different treatments in daytime hours calculated for 1 g dry matter

	Unfertilized			Fertilized		
	unflooded	flooded	in % of unflooded treatment	unflooded	flooded	in % of unflooded treatment
Whole plant	0.186 ±0.030	0.049 ±0.027	26.34	0.194 ±0.031	0.010 ±0.005	5.18
Above-ground part	0.242 ±0.041	0.060 ±0.033	24.79	0.240 ±0.042	0.011 ±0.007	4.62
Leaf blade	0.545 ±0.094	0.135 ±0.026	24.77	0.755 ±0.030	0.032 ±0.007	4.26
Root	0.817 ±0.122	0.270 ±0.158	33.05	1.032 ±0.177	0.074 ±0.038	7.23

decrease. While in the unfertilized treatment the root weight of flooded plants was 75.70% of the unflooded ones, this ratio in the fertilized treatment was only 59.51%. These values show that flooding causes a significant root decay. Since the greatest resistance to water flow in plants is usually in the roots, their partial destruction should promote a more intensive passive water movement through the plants resulting in a higher transpiration rate. The experimental results obtained do not support this assumption, very likely because the root decay caused a wilting of the aerial parts of the plants. In this context the experimental results of WENT (1943) are of interest. He stated that well aerated roots supply some substance in addition to water and minerals which is essential for shoot growth. KENDE (1965) found that roots synthesize kinetin or kinetinlike substances.

Table 3

Dry weight (g) of maize plants harvested on 26 July

	Unfertilized		Fertilized	
	unflooded	flooded	unflooded	flooded
Whole plant	30.30 ±3.00	28.79 ±2.62	112.56 ±6.43	91.33 ±3.67
Above-ground part	23.38 ±2.59	23.55 ±2.50	91.31 ±7.40	78.97 ±6.69
Leaf blade	10.38 ±0.60	10.51 ±1.32	28.91 ±2.03	28.09 ±1.65
Root	6.92 ±0.63	5.24 ±0.60	21.25 ±1.61	12.36 ±4.76

The root decay caused a water content decrease in the epigeous parts of the plants, especially in the leaves. Water content of the leaf blades significantly determined the transpiration intensity (Fig. 1). On the day following the last transpiration measurements (26 July) in the unfertilized treatment, the total water content of leaf blades of unflooded plants was 70.39% and of the flooded ones 53.30%. In fertilized treatment the difference was even greater. The total water content of leaf blades in the unflooded treatment was 75.74%, but in the flooded treatment only 36.09%.

The water content of leaves and of the whole plants played an important role in the transpiration reaction to one of the most important transpiration-affecting meteorological factors examined in this experiment, the solar radiation. The closest correlation was calculated between the solar radiation and the sum of daily transpiration of fertilized and unflooded plants (Fig. 2). The weakest correlation was found between solar radiation and fertilized, flooded plants. These relationship results are in agreement with the well known principle according to which if the plants develop under favourable conditions their transpiration rate is better influenced by the meteorological factors than as if they grow under unfavourable conditions.

The flooding effect on cumulative transpiration of unfertilized and fertilized plants is well illustrated in Fig. 3. Both fertilized and unfertilized plants transpired more in the unflooded treatment than in the flooded one. However, while during 8 days the total transpiration of flooded plants in the unfertilized treatment was 70.56% of the unflooded ones, in the fertilized treatment this percentage sank to 31.44.

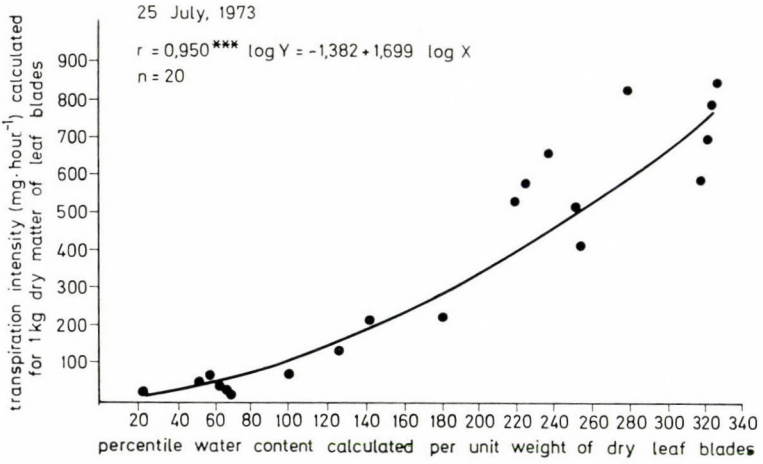

Fig. 1. The relation between the percentile water content of leaf blades and transpiration intensity. *** Significant on the 0.1% level

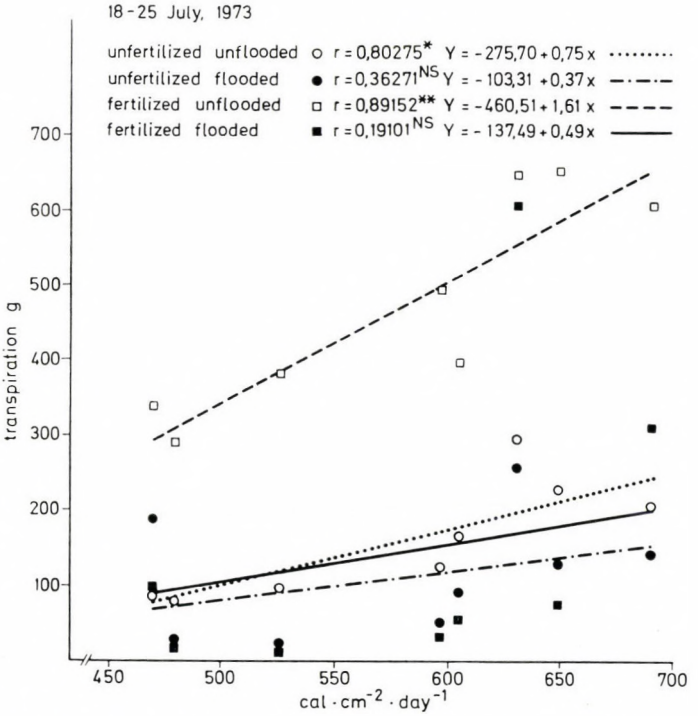

Fig. 2. The relation between solar radiation and maize transpiration of different treatments. * Significant on the 5% level; ** significant on the 1% level; NS not significant

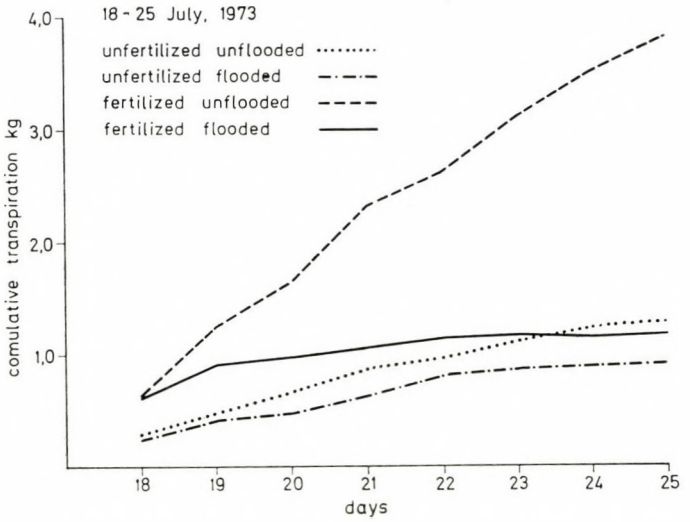

Fig. 3. Comulative transpiration of unflooded and flooded maize plants at two nutrient levels

Summary

A pot experiment was carried out in a growth-house to study the effect of flooding on maize transpiration. By covering the soil with water, anaerobic conditions were brought about in the soil. As the days progressed, the flooded plants showed a decreased per cent transpiration related to that of unflooded ones. This was the result of root decay and wilting observed in flooded plants. Though the flooded plants transpired less in both (unfertilized and fertilized) treatments, in the unfertilized treatment the flooded plants on 25 July transpired 25.09% of the unflooded ones, while in the fertilized treatment the ratio was only 4.23%. That is, flooding showed a greater transpiration decrease in better developed fertilized maize plants than in the less developed unfertilized ones.

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LAR, RGR AND NAR PARAMETERS INTERNODIALLY, AND CROP VOLATILE OIL YIELD IN PIMPINELLA ANISUM L. SOWN PERIODICALLY

By

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The internodial phenometric investigation and growth analysis of anise sown in 14 days periods have yielded the following results. Significant deviations in growth parameters and between the parameters per internode may appear in the same plant. Differences in productivity may be related with the age of the internodes, their locality, the differences in physiological activity between them as plant factors, and partly with the effect of external environment. It has been demonstrated that certain architectural elements, e.g. side shoots during the intense growth period, may result in a negative RGR value, despite the increasing LAR value.

The species reacts independently of seeding time and the developmental stage of the individual to the increasingly unfavourable effect(s) of environmental factors. The influence of late sowing on the vegetation period of anise and on the individual stages of its ontogenesis manifests itself in shortened life cycle. Under this influence first the number of the architectural elements, the side umbels are reduced. Further grades are represented by the shortening of the distance between the internodes of the main shoot and the subsequent reduction of their number. Accordingly, the productivity of the specimens and their crop yield (fructus) decreases to a significant degree.

The difference in cultivation time between the stocks sown at the earliest and the latest dates is 77 days (27.1%). The difference between crop yields is 87.4% and the measured reduction of volatile oil content 29.6%.

Introduction

Growth as a biological problem at various levels and by various approaches has been for a long time in the foreground of interest among biologists and mathematicians.

In the physiological approach, the aim became to clarify the role of growth regulators (auxin, gibberellin, kinetin), and with respect to productivity, to establish the rate of growth. However, in all approaches the complex interrelationship between development and growth must be considered. A part of the applied mathematical methods makes possible the determination of certain factors, e.g. the rate of net assimilation, if only in an indirect way. This is a considerable advantage, because the parallel and direct description of the processes of plant assimilation and dissimilation still remains problematical

owing to methodological inadequacies. The collection of necessary data and their mathematical description as well as their biological interpretation is especially difficult if growth and development occur in changing environments. In reality, one has to take into consideration this latter complex, natural but representing an involved condition system, in practically every case both in natural ecosystems and in field plant cultures.

A partial summary in Hungarian of attempts 1964 to declineate problem areas, conditions and models for a mathematical approach to plant growth had been given by O'sváth.

Representatives of the British school, F. F. BLACKMAN (1919), V. H. BLACKMAN (1968), BRIGGS—KIDD—WEST (1920), GREGORY (1918) and its more recent followers (cf. KVĚT—ONDOK—NEČAS—JARVIS 1971, CLIFFORD EVANS, 1972), respectively, have worked out or employed methods which proved to be more successful in dealing with growth ratio. The method approved by the above cited authors is based on growth analysis and defines growth as the accumulated dry weight which is produced by the assimilating surface of a single plant or plant community during a given unit of time.

A number of ecophysiologists claim that growth analysis is suitable also to determine net plant photosynthesis. In terms of photosynthesis, net production equals net assimilation (total assimilation minus respiration and the dying plant parts) during a given time unit.

According to PRÉCSÉNYI (1971), KVĚT—ONDOK—NEČAS—JARVIS (l.c.), growth rate of the biomass can, under well-defined conditions, be determined by this approach. Employing this method, BRIGGS—WEST—KIDD (l.c.), BLACKMANN—WILSON (1951), EAGLES (1969), WILSON—COOPER (1969), CLIFFORD EVANS (1972), SZUJKÓ-LACZA—FEKETE (1974) etc. have established the growth rate of some species. The criticism of growth analysis the viewpoint of bioenergetics was given by BRODY (1945); based on problems of sampling, VERNON—ALLISON (1963), KVĚT—ONDOK—NEČAS—JARVIS (l.c.) and CLIFFORD EVANS (l.c.) have made contributions.

Several workers have investigated the distribution or organic substances within the plant, but these investigations generally attempted to establish shoot/root dry weight ratio without, however, bringing it into correlation with the factor of time (cf. BROUVER, 1962).

The authors aim was in the present paper to establish the relative growth rate, RGR, the net assimilation rate, NAR and the change in the leaf area ratio LAR, per internode e.i. also those of parts within the total, in field-cultivated individual specimens sown stepwise. Furthermore, they wished to investigate crop development as well as volatile oil yield under the same conditions. At the same time, observations extended to the various developmental stages of the specimens, in order to establish the degree of interrelationship between the growth characteristics and stages in growth progress.

Material and method

Seeds of P. anisum were sown on 26, March, 9, April and 3 14, and 24 May, 1973 mean-bound type sand soil. The size of the plots amounted to 16.00 m^2. The seeds were sown at a row distance of 20 cm and sowing was repeated four times. The time of harvesting and the phenophases of the individual specimens seeded at various times are given in Table 1.

From a given plot five samples were collected at each measuring period. The specimens were sliced internodally so that the segment between two nodes (internode) had one leaf (the first internode with leaves) and the consecutive internodes one side shoot (in the case of the apical node eventually two), each segment constituting one measuring unit. The assimilating surface was measured by MEDINA—LIETH (1964) type optical planimeter. After desiccation at 80°C, dry weight was measured. At the time of seed ripening 7, August, 1973, the crop of all plots was harvested. Crop yield per plot was measured after the crop was threshed and cleaned. The content of volatile oil of the fruits with respect to the content of dry matter was established by the CLEVENGER method.

Analysis of the volatile oil was carried out by JEOL JGC-810 type gas chromatograph, considering the parameters cited below:

Column dimensions: ∅ 3 mm; 1.75
Solid support: 10% DEGS
Stationary phase: Chromosorb W sil. 60/80 mesh.
Column temp.: 100—200°C, Rate (minute: 8°C) min
Detector temp.: 220°C Injection temp.: 210°C
Detector: FID dual, Range: 1 mV
Carrier gas: N_2, Flow rate: 15 ml/min
Chart speed: 5 mm/min. Anal time: 30 min

Results and discussion

According to the phenological data recorded in 1973, which established the developmental stages of the plant, two leaves of the rosette were still present on *P. anisum* at the initial period of measurement; on the main axis the umbel was in phenophase 31. 4. 2 (c.f. SZUJKÓ-LACZA 1975 mscr), the inflorescence axes of the third order and their fructiferous primordia have already developed. On the bicarpel the petals had a greenish colour above their midvein, and whitish at the marginals. The side umbels were slightly larger in size than the main umbel. Based on data collected in 1974, this phase is of a significant importance with respect to the assimilating surface. According to daily records made in 1974, the assimilating surface will grow for an additional 10 days, a growth owing to the developing side shoots.

Table 1

Development stadia and phenophases of Pimpinella anisum in 1973

Age in days	Reading and collecting date		Stadia and phenophases			
	days	months	21—23	31—36		41—43
88	21	6	21.4.2—23.2	31.4.2—32.1;	34.3.1—34.3.2	41.2
99	2	7	21.4.2—23.2	32.3.1—32.3.2;	34.3.2—35.1	41.3
109	11	7	21.4.2—23.2	33.1.1—33.1.2;	35.3.3—35.2	41.3
119	21	7	21.6 —23.2	33.1.3—33.1.2;	36.1.1—36.1.2 (35.3.3)	42.3
129	31	7	2.2 —23.2	33.2.1;	36.1.1—36.1.3	43.1
136	7	8		33.2.2;	36.2.1—36.2.2	43.2
79	21	6	21.2.4—23.2	32.1;	34.3	41.1
90	2	7	22.2 —23.2	32.3.1;	34.3.1	41.2—41.4
100	11	7	22.2 —23.2	33.1.1—33.1.2;	35.3.2—35.3.3	42.1
110	21	7	22.5 —23.2	33.1.2;	35.3.1—36.1	42.2
120	31	7	23.2	33.1.3;	36.1.2	43.1
127	7	8		33.2.2;	36.1.3	43.2
70	21	6	21.2.4—23.2	31.4.2		41.1
81	2	7	21.4.2—23.2	32.1;	34.4.1	41.2
91	11	7	21.4.2—23.2	32.3.1—32.3.3;	35.3.1	41.2
101	21	7	22.2 23.2	33.1.1—32.3.3;	35.3.3	41.4
111	31	7	22.2 —23.2	33.1.3—33.1.2;	36.1.1—36.1.2	43.1
118	7	8	22.2 —23.2	33.1.3;	36.1.2—36.1.3	43.1
49	21	6	21.2.4—23.1	(31.1)		
60	2	7	21.2.4—23.2	31.3.1;	34.3	
70	11	7	21.2.4—23.2	32.1;	34.3	41.1
80	21	7	21.2.4—23.2	32.3.2—32.3.3;	35.3.1—35.3.2	41.3—41.4
90	31	7	22.4 —23.2	32.3.2;	35.3.3	42.1
97	7	8	22.4 —23.2	33.1.1;	35.3.3	42.1
29	21	6	21.2.3—21.3			
40	2	7	21.2.4—22.5			
50	11	7	21.2.4—23.1	31.1		
60	21	7	21.3.2—23.2	31.2		
70	31	7	21.4.2—23.2	32.1	35.1	41.3
77	7	8	23.2 —23.2	32.1 —32.2;	35.2	42.1

In 1973, the LAR of the internodes of the individual specimens has reached its maximum in 10 days (cf. Table 2). Based on observations made in 1973 and 1974, identical phenophases will occur within very close time limits.

Table 2 indicates that the maxima of LAR, RGR and NAR occured at the same time, with the exception of the 6th and 7th internodes. During the next measurement period, LAR decreased on these internodes, whereas RGR and NAR still increased. Increase of RGR of these two internodes took place by NAR, as opposed to the previous 10 day period when the increase of RGR was possibly related to both (LAR and NAR). In the fourth decade period, LAR decreased to one-half or nearly one-third owing to the gradual withering of leaves from the base upwards which partly explains the negative-signed RGR and NAR. The phenophases, the LAR, RGR and NAR values indicate in concordance that the reduction of the assimilating surface proceeds gradually from the base toward the apex (Tables 1 and 2). Depending on the rate of abscising of stock and stem leaves, already of decreasing value, the sign of the two other growth characteristics turns negative successively.

The effect of successive sowing can be evaluated by comparing the data of Tables 2 and 3. Sowing was carried out at intervals of 14 days. Difference in plot treatment under the same environmental conditions was registered by the variations of age and development of the plants. The three growth characteristics indicated that 9 April was the favourable seeding period (in contrast to crop yield). Within the same periods of investigation, the decay of the assimilating surface and with it the decrease of LAR (Tables 1) 10 day period when the increase of RGR was possibly related to both (LAR and NAR). In the fourth decade period, LAR decreased to one-half or nearly one-third owing to the gradual withering of leaves from the base upwards which partly explains the negative-signed RGR and NAR. The phenophases, the LAR, RGR and NAR values indicate in concordance that the reduction of the assimilating surface proceeds gradually from the base toward the apex (Tables 1 and 2). Depending on the rate of abscising of stock and stem leaves, already of decreasing value, the sign of the two other growth characteristics turns negative successively.

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Table 2

Internodial RGR, LAR and NAR

(Seeding time

	RGR						
Total Internodes	.0480	.0409	.0191	—.0150	.0056	55.48	44.17
1.	.0247	—.1018	.0272	—.0154		68.43	56.96
2.	.0806	—.0451	—.0054	—.1019		53.84	45.68
3.	.0634	.0146	—.0131	—.0305		68.49	51.98
4.	.0270	.0189	.0118	—.0199		49.37	42.03
5.	.0560	.0329	.0187	—.0309		58.07	45.53
6.	.0760	.0622	.0241	—.0241		51.89	44.14
7.	.0415	.0430	.0219	.0241		48.21	42.93
8.	.0789	.0138	.0597	—.0180		36.43	32.52
9.	.0876	.0342	.0444	—.0068		62.73	53.03
Age, in days	88	99	109	129	136		
Period	1	2	3	4	5	1	2

Table 3

Internodial RGR, LAR and NAR

(Seeding time:

	RGR						
Total Internodes	.0547	.0643	.0167	—.0032	—.0088	59.98	45.04
1.	—.0140	.0742	—.0480	—.4748		66.18	30.45
2.	.0221	.0460	—.0172	—.0375		71.14	55.87
3.	.0206	—.0061	.0000	—.0288		64.13	60.42
4.	.0533	.0375	.0061	—.0307		56.85	40.96
5.	.0607	.0044	.0578	—.0158		58.13	58.76
6.	.0652	.0847	.0000	.0169		58.60	45.94
7.	.0632	.0610	.0298	—.0176		54.67	47.83
8.	.0611	.0740	—.0368	.0972		55.84	40.95
9.	.0484	.1596	.0321	—.0030		62.17	34.80
10.	.0705	.0606	.0197	.0273		52.02	39.00
Age, in days	90	100	110	120	127		
Period	1	2	3	4	5	1	2

values of Pimpinella anisum L.

3. 26. 1973)

LAR			NAR				
31.28	24.05	24.05	.0870	.0916	.0608	—.0636	.0287
20.32	17.38		.0360	—.2009	.1427	—.0932	
28.89	22.24		.1460	—.1015	—.0194	—.4390	
31.39	22.89		.0971	.0292	—.0419	—.1487	
31.63	21.97		.0554	.0451	.0372	—.1002	
30.80	27.20		.0996	.0724	0.0604	—.1149	
34.11	26.15		.0728	.1380.	.0703	—.0946	
33.74	22.63		.0859	.0991	.0648	.1067	
29.57	26.47		.2032	.0425	.1982	—.0682	
32.40	21.05		.1442	.0639	.1349	—.0330	
3	4	5	1	2	3	4	5

values of Pimpinella anisum L.

9. 4. 1973)

LAR			NAR				
34.20	27.05	27.05	.0893	.1391	.0487	.0117	—.0350
20.00	00.02		—.0221	.2331	—.2516	.0841	
34.15	26.52		.0317	.0811	—.0511	—.1414	
45.50	28.07		.0320	—.0100	—.0142	—.1043	
36.03	33.25		.0913	.0904	.0168	—.0949	
44.66	32.50		.1013	.0076	.1205	—.0493	
37.59	31.16		.1080	.1795	—.0054	.0540	
35.06	27.11		.1145	.1255	.0847	—.0650	
33.27	25.28		.1090	.1739	—.1109	.3686	
26.94	22.24		.0757	.4146	.1181	—.0134	
30.08	20.58		.1356	.1509	.0654	.1335	
3	4	5	1	2	3	4	5

Population sown on 4, April. At the beginning of the investigation period, all stock and stem leaves of the individuals were sound, the main umbel was in phenophase 31. 4. 2., like the plants sown at the earliest date; however, the side umbels were grossly retarded in their development.

During the first 10 days period between the set of specimens seeded at various dates this group of plants have exhibited the greatest LAR, RGR and NAR. However, in the second period the stock leaves have already abscised (Table 1), simultaneously with a significant reduction in LAR, and on the low and upper internodes also RGR and NAR showed a negative value. On the other hand, the side shoots and their umbels have developed during this period which might be responsible for the negative sign of NAR.

During the third decade, RGR and NAR turned positive on practically all internodes. It follows that the rate of net assimilation of the fully developed side shoots compensated for the loss of photosynthesis caused by the loss of leaf surface which is represented by the dead stem leaf. BERTALANFFY (1941; 1951; 1957, cf. O'SVÁTH, 1964) divided the growth differential in time into two opposite the anabolical and catabolical, processes taking place within the organism.

Considering the phenological data of Table 1 and the data associated with RGR and LAR in Table 4 as well as BERTALANFFY's observations (l.c.) one may infer that within the identical population, under changing external conditions and depending on the developmental stage of the individuals, the

Table 4

Internodial RGR, LAR and NAR

(Seeding time:

	RGR						
Total Internodes	.0795	.0263	.0168	.0335	.0009	64.16	46.21
1.	—.0336	.0072	—.0065	.0470		82.61	50.90
2.	.0336	—.0032	.0074	.0194		73.08	44.59
3.	.0375	—.0072	.0758	—.0375		67.15	56.19
4.	.0446	—.0248	.0668	.0228		72.59	55.29
5.	.1070	—.1286	.1729	—.0016		58.77	53.26
6.	.1237	.0225	.0388	—.0094		60.05	42.72
7.	.1099	.0511	.0191	.0959		71.19	51.65
7.	.1564	—.0053	.0535	.0357		54.73	49.88
9.	.2906	—.1001	—.0262	—.0744		30.33	31.83
Age, in days	81	91	101	111	118		
Period	1	2	3	4	5	1	2

ratio of the anabolical and catabolical processes respectively varies within the various plant part as well as in the whole plant.

NAR proved to be a rather sensitive indicator of the assimilation and dissimilation rate of the several plant parts, s.c. of the internodes.

Table 5 gives the data of plants which had only 4 internodes and no umbel primordium apparent on the apex of the shoot axis at the beginning of measurements, namely 50 days after the seeding date (cf. Table 1). Related to the above, an acceleration in plant development could be observed during the first days of the investigation. During the second decade of investigation the plants had a completely developed foliage, the inflorescence primordium was apparent and some of the side shoots have even reached the height of the main umbel. At this time, LAR, RGR and NAR of the 70 days old individual specimens reached their maximum, with the exception of the first and seventh internodes. Subsequently the value of LAR decreased to a lesser rate than in plants of an earlier seeding time, and the values of RGR and NAR remained positive until the end of the fourth decade, with the exception of the second and third internodes. Although reduction in LAR during the fifth decade was slight, the RGR and NAR values turned negative in case of five internodes out of eight. Phenology here indicates rather the desorganization of the already existing ones than the growth of new organs. A comparison of the data given in Tables 3, 4, 5 and 6, reveals that specimens sown earlier also had negative

values of Pimpinella anisum L.

14. 4. 1973)

LAR			NAR				
38.35	27.59	27.59	.1177	.0568	.0438	.1202	—.0038.
17.94	8.87		—.0409	.0154	—.0384	.5232	
31.78	18.90		.0461	—.0187	.0234	.1054	
37.19	22.11		.0546	—.0127	.1949	—.1912	
40.54	27.30		.0607	—.0447	.1538	.0832	
42.47	29.24		.1666	—.2199	.3614	—.0056	
36.19	39.70		.1855	.0527	.1011	—.0235	
42.06	28.43		.1424	.0978	.0453	.3222	
35.94	20.69		.2500	—.0106	.1462	.1706	
39.57	39.59		.7816	—.2949	—.0724	—.1828	
3	4	5	1	2	3	4	5

Table 5

Internodial RGR, LAR and NAR

(Seeding time:

	RGR						
Total Internodes	.1086	.0622	.0584	.0295	—.0410	92.73	66.85
1.	—.0368	.0000	.0201	.0310	.0411	105.09	59.67
2.	.0511	.0203	.0000	.0405	.0151	103.38	72.36
3.	.0588	.0707	—.0061	.0560	.0191	102.57	69.00
4.	.0539	.0568	.0140	.0197	—.0162	91.79	77.38
5.		.0713	.0490	.0121	—.0128		64.97
6.		.1018	.0588	.0054	—.0781		66.79
7.		—.0159	.0480	.0566	—.0809		68.43
8.		.0961	.0388	.0619	.0106		40.11
Age, in days	60	70	80	90	97		
Period	1	2	3	4	5	1	2

RGR and NAR values at this time. Within the same period, a decrease in growth rate can be registered in all plots, a fact pointing to the effect of an external complex of conditions which results in an identical reaction in the plants of all plots regardless of the phenophase or the age of the specimens.

Table 6

Internodial RGR, LAR and NAR

(Seeding time:

	RGR						
Total Internodes	.0223	.0770	.2944	—.0379	—.0990	1262.22	1275.33
1.	.0000	.0000	.2303	—.0981	.0000	701.25	872.50
2.		.0451	.2455	—.0560	.0319		1550.00
3.			.2708	—.0405	.0319		
4.			.2148	—.0693	.0000		
5.			.2303	.0000	—.0319		
6.			.2079	.0981			
Age, in days	40	50	60	70	77		
Period	1	2	3	4	5	1	2

values of Pimpinella anisum L.

3. 5. 1973)

LAR			NAR				
50.02	43.17	39.19	.1115	.0818	.1147	.0679	—.1052
30.00	16.69	15.66	—.0372	—.0019	.0722	.1887	.2607
42.58	33.60	26.63	.0496	.0260	—.0019	.1191	.0565
59.21	45.00	33.60	.0561	.0893	—.0102	.1212	.0567
60.09	47.06	45.28	.0599	.0647	.0242	.0417	—.0358
51.60	47.61	45.85		.0966	.0936	.0255	—.0279
48.18	42.32	46.40		.1319	.1191	.0128	—.1658
66.00	51.93	49.03		—.0208	.0720	.1067	.1627
49.40	43.90	36.72		.0598	.0784	.1388	.0289
3	4	5	1	2	3	4	5

According to Tables 1 and 5, specimens sown on 3 May have passed through a shorter time span in each developmental stage.

In the case of the lower internodes, the NAR value evidence only a slight increase in the photosynthetic activity, or in some periods of its absence,

values of Pimpinella anisum L.

24. 5. 1973)

LAR			NAR				
128.60	90.91	105.90	.0029	.0053	.1463	—.0418	—.0904
96.14	59.46	139.00	.0003	.0002	.0001	—.1625	.0001
141.84	93.27	85.67		.0028	.1214	—.0606	.0371
171.88	109.60	93.22			.1044	—.0375	.0341
140.11	102.67	139.67			.1162	—.0671	—.0034
187.64	95.20	122.22			.0873	—.0021	—.0261
110.00	92.09				.1494	—.1034	
3	4	5	1	2	3	4	5

which of course affects the RGR value as well. The plants remained short although the eight internode was developed. As a consequence of the elongation inhibition, the specimens reacted to late seeding with shortening and with the weak development of the side umbels. The stepped sowing thus shortens growth season and some ontogenetic stages of the plant. Results of late seeding resemble the well-known phenomena common among the short-statured, so-called nunatak plants which develop during the brief vegetative season at high altitudes.

The last sowing was done on 4 May. At the beginning of measurements, even the cotyledons were present and only the first internode was developed. 20 days later, the second internode appeared and after an additional 10 days the 59 day old specimen displayed its main umbel and some of the side shoot primordia. The LAR value has surpassed the twofold of populations sown earlier (Table 6), with the accordingly high and positive values of RGR and NAR. In this case, the RGR value was in closer relation to the LAR value. During the fourth decade, LAR of the 69 days old plant showed a slight decrease and the RGR and NAR values were negative. With respect to RGR the uppermost internode is an exception. During the fifth decade, LAR exhibited an increase due to the side shoots, but NAR showed a negative value, or zero, or a very low positive value.

It is characteristic to all plants of the plot that they are extremely short and have, at the most, 6 internodes. The reproductive organs are weakly developed with exception of those on main umbel. Those of the side shoots proved to be infertile in various ways.

Plants sown as the last reacted to the unfavourable external environment by extensively short stature, but also by a decrease in the number of internodes. It can be assumed that the unfavourable external effect complex influenced the reactions regulated by auxin and gibberellin through which both body elongation of the entire plant and the full development of the side shoots became indirectly and internally inhibited.

Crop yield, volatile oil content and the ratio of its components

Our measurements indicate that sowing time significantly influenced the crop yield of anise (*Pimpinella anisum*, Table 7) as well. Sowing done at the beginning of April (4.09) have already resulted in a 39% drop in crop yield as compared to that of the earliest sowing data (3.26) which, however, is not the most acceptable date with respect to growth parameters. Late sowings (May) resulted in a low crop yield, owing partly to the absence of some architectural elements (such as the side shoot) and partly to the infertility of flowers.

According to Table 7, the change in the amount of volatile oil present in the dry matter (Anisi fructus) is a function of seeding time. The volatile oil

Table 7

Crop yield, volatile oil content and the quality of the volatile oil of Pimpinella anisum as a function of sowing date (1973, Soroksár)

Sowing date	Crop yield		Volatile oil content in % of absolute dry matter	Content of anethol in the volatile oil, in %
	kg/plot	q/ha		
3.26	1.66	10.40	2.84	86.5
4.09	1.06	6.64	2.76	89.2
4.14	0.73	4.58	2.56	92.3
5.03	0.43	2.66	2.24	90.1
5.24	0.21	1.28	2.00	90.0
SD 5%	0.16	1.00	0.18	—

Table 8

Main weather factors covering the period from spouting to seed ripening (1973, Soroksár)

Sowing date	Precipitation in mm	Total of abs. temperature in C	Number of hrs of sunshine
3.26	229.1	1958.9	882
4.09	217.1	1814.3	809
4.14	191.1	1671.4	750
5.03	164.6	1475.2	640
5.24	162.6	1187.8	490

eontent of stocks sown earlier was 30% higher than that of those sown by the end of May. However, anethol which determines the quality of the volatile oil was of a higher grade in the case of plants sown at a later date. With respect to crop yield and the content of volatile oil, the results of stepped sowing experiments done with *Anethum* in 1968—71 and with *Coriandrum* in 1971—73 were in fair agreement with the results of stepped sowing experiments carried out with anise.

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THE STUDY OF THE LOCALIZATION OF VOLATILE OIL IN THE DIFFERENT PARTS OF SALVIA SCLAREA L. AND SALVIA OFFICINALIS L. BY APPLYING 2^{14} C SODIUM-ACETATE

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Using 2^{14}C Na-acetate and inactive histochemical methods in comparison, the biosynthesis and localization of volatile oils, biochemically already verified by the authors (1974), were studied. It was established that the localization conditions, and therefore functions, of the glandular and covering trichomes of various types are different.

Introduction

One of the perspective fields of applying radioactive precursors is the investigation of the localization and distribution of the substances in plant tissues. Medical diagnostics uses this method extensively, while in botany it has been only a sporadically applied method so far. Recently, the examinations by one of the authors (VERZÁR-PETRI, 1971) concerned the distribution according to tissue areas of alkaloids forming in the secondary metabolic turnover for example in *Nicotiana*, *Vinca minor*, *Datura innoxia*, *Valeriana officinalis*. Until now only inactive histochemical methods were available (TUNMANN—ROSENTHALER, 1931; SÁRKÁNY et al., 1966 etc.,) besides electronmicroscopical studies (AMELUNXEN, 1965), therefore, we proposed to study with histoautoradiographical methods the localization of volatile oil in the two *Salvia* species. Although the 2^{14}C Na-acetate precursors are not specific ones, since they are the precursors of several types of compound (volatile oils, steroids, carotidoids) as well as of fatty acid metabolism, it is a verified fact (LUCKNER, 1969; VÁG-ÚJFALVI and TYIHÁK, 1963) that the acetyl-residue from the acetyl CoA biosynthesizes the mono- and sesquiterpenes through mevalonic acid.

Material and method

Two characteristically volatile-oileferous plants were chosen for the examinations: *Salvia sclarea* L., the muscatel sage, belonging to the *Labiatae*

family, and *Salvia officinalis* L., the garden sage, for the comparative analyses. Both plants are important also industrially. *Salvia sclarea* is an important raw material of parfume industry, while *Salvia officinalis* in pharmaceutical field.

By using the radioactive precursors, we expected an answer to methodological questions, and also to the extent of localization taking place in the trichomes during investigations. We also wanted to evaluate the differences arising during the infiltration within the species and between the two species. *Salvia sclarea* L. and *Salvia officinalis* L. were collected from the University Botanical Gardens, Budapest.

A solution of 4.25×10^3 concentration was prepared from $2^{14}C$ Sodium-acetate of 0.5 mCi (4.816 mCi/mMol) activity; 25 ml of this solution was used for the incubation of young shoots. Incubation time was 7 days = 168 hours. After treatment, contact histoautoradiograms were taken of leaves. The X-ray plates were developed for 14 days. During exposure, they were kept at +4°C, excluded from light. After development, the photographs were taken from these X-ray films.

Results of investigation

A) *The trichomes of Salvia species*

Concerning *Salvia officinalis*, detailed data are available in KARSTEIN's pharmacognostical handbook on the structure of *Labiatae*-type hairs (glandular hair with a big head) and of glandular hairs with a small head in various species.

Concerning covering trichomes, the data refer only to one type, viz. to a glandular hair with 5-celled heads, mentioned as covering trichome developed without plasm. Similar data are found in the Sixth Hungarian Pharmacopea and also in the textbook by HALMAI—NOVÁK's Pharmacognosy (1963).

In the course of investigations, we found the above-mentioned types of glandular hairs in various distribution on the foliage leaf, to be discussed later. Concerning covering trichomes, the descriptions can be extended to two types. Accordingly the trichomes of *Salvia officinalis* are as follows:

Glandular hairs with small heads, with monocellular stem and monocellular head, the same with 2—4-celled heads. Typical *Labiatae* glandular hair with 8-celled head.

The covering trichomes are of three types: monocellular papillae with plasm content in all cases; monocellular, long, winding, laniform trichomes; and 5-celled rigid, setiform covering trichomes. These may attain a length of 450 μ. (The Pharmacopea refers to this as a specific feature.)

The so-called small-headed glandular hairs appear in great number on the abaxial surface of the leaf, along the veins. On the adaxial surface of the

leaf they occur mainly in the intervenae spaces. The location of the covering trichomes is similar. Papillae can be observed intervenially on the adaxial surface of the leaf, and on the abaxial surface along the veins. *Salvia sclarea* is of a similar tissue construction. It is only the small-headed glandular hair with a neck cell that deviates by forming merely one stem cell. On the inflorescence axis there are nearly exclusively glandular hairs with an elongated basal cell, a monocellular neck and head.

The types of the covering hair are considerably richer than in *Salvia officinalis*. In a great majority of the cases, the hair type consists of 3—4 cells, with a large basal cell, and acute tip, but there are also stout monocellular papillae, and bicellular, acute or obtuse tricomes. Very characteristic is the tricellular covering trichome, situated on two protuberant emergentia cells. The latter breaks off very easily and therefore used to observe.

As regards the substance content of trichomes, our histochemical examinations provide further details.

First, however, the performance of the tested reagents of different types should be discussed.

It can be stated that some of the reagents developing volatile oil used in paper- and thin- layer chromatography furnish negative results in the course of histochemical examinations, e.g. the EP reagent and $SbCl_3$. The negative behaviour of the EP reagent is probably due to the fact that it gives no colour reaction with terpenes other than azulene, and the latter is not found in *Salvias*. The tested $KMnO_4$ and $FeCl_3$ reagents appear in characteristic colours but not specifically in the tissues, while the cc. H_2SO_4-vanilline provides a specific colour reaction with (*Labiatea*-type) hairs containing volatile-oil. After a certain time it dissolves the tissue, but in combination with infiltration it can be used satisfactorily.

Several histochemical dyes were tried which all produced a colour reaction (Tables 1 and 2).

Osmium acid gives an intense black colour reaction.

Nile-blue dyed bright blue or greenish blue the large glandular hairs with volatile oil content.

It is worthy of attention that it dyed the papillae and the other covering trichomes as well, with special regard to the second or the so-called basal cell counted from the apical cells of the long covering trichomes. Toluene blue and its variety combined with KJ_3 behaved similarly. The volatile oil drops observed by SZENTPÉTERI (in SÁRKÁNY et al., 1966) were not found in our examinations. Both dyes being plasm dyes coloured also the nucleus to a darker shade, which verifies the plasm content of the covering trichomes. The heterochromatic and specific behaviour of Rosanilin must also be emphasized.

The *Labiatae*-type glandular hairs belong in the group of large-headed glandular hairs. Two of its type could be observed on the plant examined,

Table 1

Colour reactions of trichomes with thin layer chromatographic reagents

Type of hair	Reagents				
	R-$SbCl_3$	R-$KMnO_3$	R-KJ_3	cc. H_2SO_4-vanillin	R-$FeCl_3$
Salvia officinalis					
Covering trichome	Basal cell yellow	Brown	Basal cell yellow	Negative	Negative
Glandular hair with monocellular head	Negative	Darkbrown	Yellowish-brown	Negative	Negative
Glandular hair with bicellular head	Negative	Darkbrown	Yellowish-brown	Cyclamen	Negative
Labiatae					
Glandular hair with large head	Negative	Brown	Brownish-yellow	Orange-red cyclamen	Greenish-gray or colourless
Salvia sclarea					
Covering trichome	Negative	Brown	Basal cell apical cell yellow	Negative	Negative
Glandular hair with monocellular head	Negative	Lightbrown	Yellowish-brown	Negative	Gray
Glandular hair with bicellular head	Negative	Lightbrown	Yellowish-brown	Yellow	Gray
Labiatae					
Glandular hair	Negative	Darkbrown	Negative	Cyclamen violet	Gray

Table 2

Colour reactions of the trichomes with volatile oil dyes

Hair type	Dyes					
	Toluene blue	Toluene blue KJ · J_2	Rosanilin	Sudane III	Nile blue	Osmium acid
Salvia officinalis						
Covering trichome	Blue	Bluish-green	Negative or pink	Apical cell red	Greenish	Negative black grains
Glandular hair with monocellular head	Blue	Yellowish-brown	Red	Red	Green	Gray
Glandular hair with bicellular head	Light	Yellowish-brown	Pink	Negative	Blue	Black
Labiatae						
Glandular hair with large head	Negative or gray	Yellow	One part yellow, another part red	Yellowish	One part yellow, another part red	Gray
Salvia sclarea						
Covering trichome	Blue	Yellow	Pink or negative	Negative	Greenish-blue	Negative
Glandular hair with monocellular head	Blue	Darkblue	Red	Red	Greenish-blue	Negative or black grains
Glandular hair with bicellular head	Blue	Darkblue	Pink	Negative	Blue	Black
Labiatae						
Glandular hair with large head	Blue	Darkblue	Red	Red	Greenish-blue	Grey

coloured also differently by dyes. In one type the head cell is apparently solid: presumably other substances are also present, or the oil turned resinous, while in the other type the division into 8 heads and the homogeneous staining is conspicuous. Assumably it contains the volatile oil in a clearer state. Rosaniline produces a yellow reaction in *Salvia officinalis*, while a bright red in *Salvia sclarea*. This permits the inference that the volatile oil composition of the large-headed glandular hair is different in the two species. Characteristically, in the small-headed glandular hairs and in the 5-celled covering trichomes the neck-cell below the apical or head cell stains also a bright red, indicating that they also secrete volatile oil.

The head cells of the long-stemmed glandular hairs occurring on the inflorescence axis of *Salvia sclarea* stain strongly with all reagents. The differences concerning the volatile oil components of the divers trichomes imply that various volatile oil components accumulate in then, indeed in certain cases even other substances may be secreted. For example, tannic acids, staining to a greenish colour with $FeCl_3$ may appear also in the *Labiatae* glandular hairs. Intense resinification could be observed in *Salvia sclarea* with alcoholic tests or with the vapour of cc. HCl. In the same species, fatty oil also accumulates beside the volatile oil in glandular hairs with a monocellular head; it strongly stains with Sudane III after evaporation of the volatile oil.

It is only with glandular hairs with a bicellular small head that the volatile oil can be observed in a pure state, on a variety of the *Labiatae*-type glandular hairs occuring on young leaves.

The volatile oil content of neck cells in the pedunculate glandular hairs was therefore verified. (The neck cell stains homogeneously with the head cell.) Secretion can be detected in the basal cells of the covering trichomes and also in the apical and subapical cells, which collapse easily; this observation is in contrast with data published in the literature so far.

Examinations with the histochemical reagents testified merely that the location of volatile oils in the developed shoots and flowers of *Salvia sclarea* is indeed in the glandular hairs.

No indication has been found in the literature whether the covering trichomes can, under certain conditions, take over the role of glandular hairs, especially with reference to localization. In the course of our investigations we found that the covering trichome invariably contained plasm, and when certain dyes, for example, Rosanilin, Nile blue were applied, the colour reaction was identical with that of the glandular hairs. The histoautoradiogram, taken with radioactive isotope, only corroborated the inference that the plasm of the covering trichome can take also the role of the plasm of the glandular hair. Further, it could also be observed that secretion takes place not definitely in the epidermal growths but that the subepidermal cell layers transfer the already secreted volatile oil into the glandular hairs where it localizes.

The secretion in that site "the pressing below the cuticle", in the process which was electron-microscopically observed in *Mentha piperita* by the German researcher AMELUNXEN.

B) *The results of histoautoradiography*

The two representatives of the genus *Salvia* are characteristic types of plants containing volatile oil; in them, the production of sesqui- and monoterpenes, characteristic of the family, takes an important place. This process is enacted vigorously in our two plants selected for study. Subsequent to the chemical and histochemical (inactive histochemical) examinations (VERZÁR-PETRI—THEN, 1969; 1970; VERZÁR-PETRI and THEN, 1974), the thin layer chromatograms and histoautoradiograms, taken with radioactive isotopes have unequivocally answered the initial question: the method is suitable for the investigation of the tissue distribution of the chosen precursor. The 7-day incubation period proved to be satisfactory for the infiltration of the isotope into the mechanism of the terpene biosynthesis.

The results of our histochemical investigations made on inactive material were unambiguously confirmed by the results obtained after the applicaton of the isotope. It was established that the isotope infiltrates the cells of the epidermis, further, that the trichomes become radioactive and that their intensity differs from that of the plasm.

The extent of blackening allowed even a semi-quantitative evaluation. After an incubation of 168 hours, it could be observed in all cases that some radioactivity appears in the boundary between the cell wall and the plasm in the head cells of the small-headed glandular hairs, in both species (Figs 1a and 1b).

The glandular hairs mentioned above occur in great number along the veins and intervenally on the abaxial surface of the leaf.

This trichome type (Fig. 2) was in all cases stained by the histochemical reagents tested by us so far, but the colour reaction was not specific either within species, or between two species, and in the course of their reactions with R-$FeCl_3$, or osmium acid differences in colour can be observed. Thus, no characteristic volatile oil components are found here, but there is a great probability that, beside terpene acid and fatty oil, other substances of an oxydizing or acidic character appear. The volatile oil components emerge only at a later stage of biosynthesis. Accordingly, activity also is of a lesser rate.

On the basis of literature data and of our own examinations, it can be said that *Salvia sclarea* synthesizes a considerable amount of terpene acid. Therefore its trichomes also present a greater accumulation of activity then the glandular hairs of the same type in *Salvia officinalis*.

Glandular hairs with two- and four-celled heads (Figs 3 and 4) display when treated with 1% solution of cc. H_2SO_4 vanillin, a characteristic colour difference. Since the reagent is definitely an oil reagent, the tissue reaction obtained here implied that this type of glandular hairs contains the volatile oil in a pure state. The colour difference observed between the two species, cyclamen and yellow, is a difference in concentration and component at the same time. The latter is a characteristic and typical difference between the two species (GUENTHER, 1952; LUCKNER, 1967).

Fig. 1a. Histoautoradiogram of *Salvia officinalis* L. M_1 = small-headed glandular hair; M_2 = *Labiatae*-type glandular hair; F = covering trichome

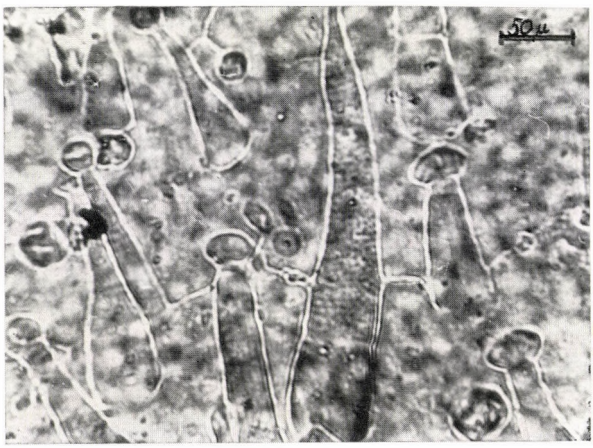

Fig. 1b. Histoautoradiogram of *Salvia sclarea* (section of an intervenal area)

Our histoautoradiographical results show that in the case of *Salvia sclarea* (Figs 5a, 5b, 5c) radioactivity is very strong, while in *Salvia officinalis* empty (Fig. 6) and charged (that is strongly active) (Fig. 7) glandular hairs can both be found. Between the glandular hairs with 4 celled head and the *Labiatae*-type glandular hairs a functional difference can be assumed, confirmed by our radioactive isotope experiments.

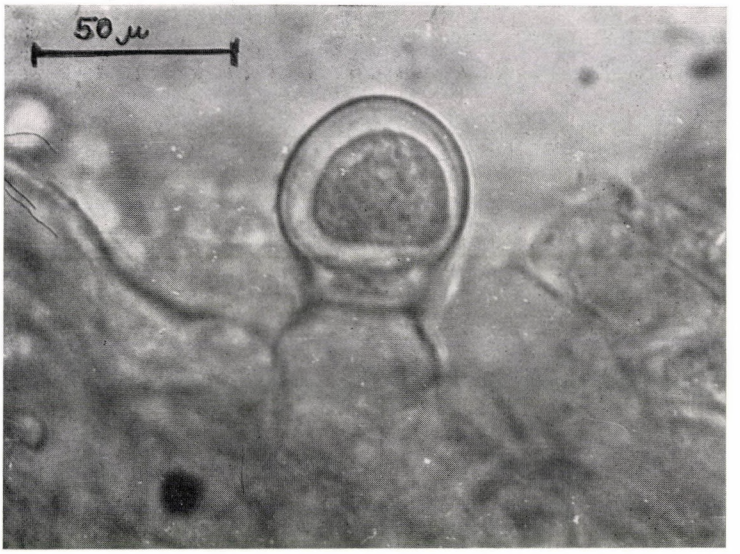

Fig. 2. Glandular hair with monocellular head after $FeCl_3$-reaction (stained gray) on the foliage leaf of *Salvia sclarea* L.

Fig. 3. Glandular hair with four-celled head of *Salvia officinalis* L., treated with osmium acid

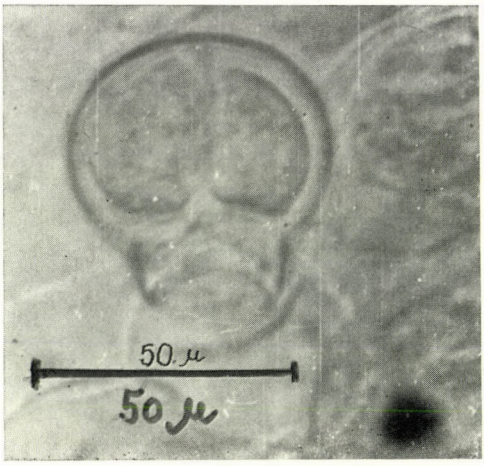

Fig. 4. Glandular hair with bicellular head of *Salvia sclarea* L., in the untreated state

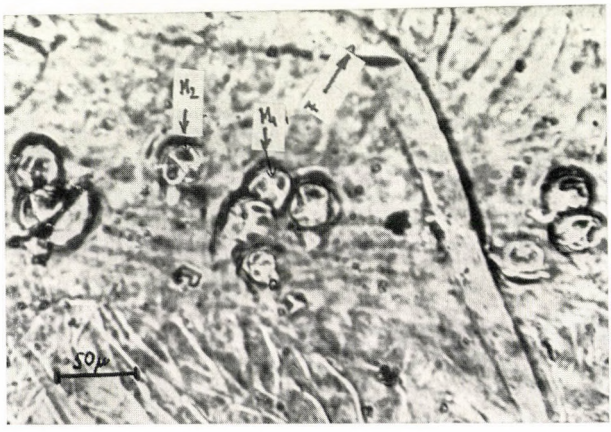

Fig. 5a. Section of epidermis in *Salvia sclarea* L. M_1 = glandular hair with four-celled head

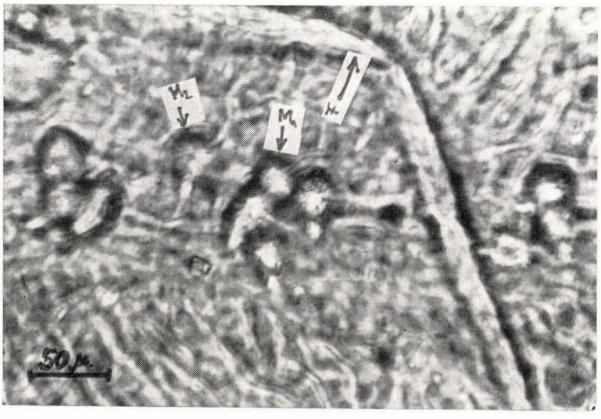

Fig. 5b. Section of epidermis in *Salvia sclarea* L. M_2 = *Labiatae*-type glandular hair

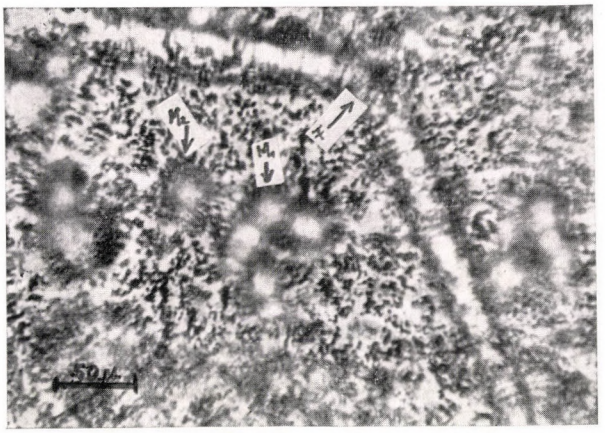

Fig. 5c. Salvia sclarea (cell-wall level), F = covering trichome

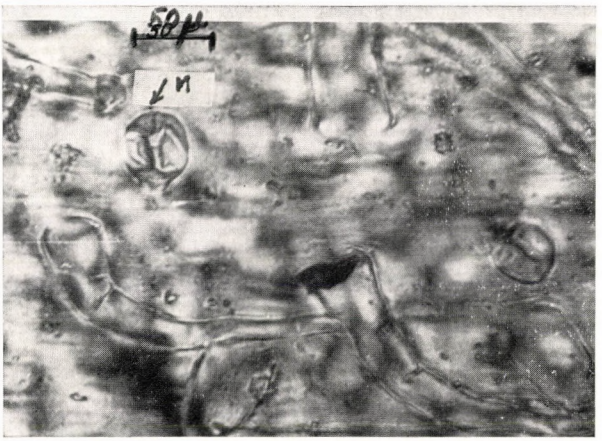

Fig. 6. Section of epidermis in *Salvia officinalis.* M = glandular hair

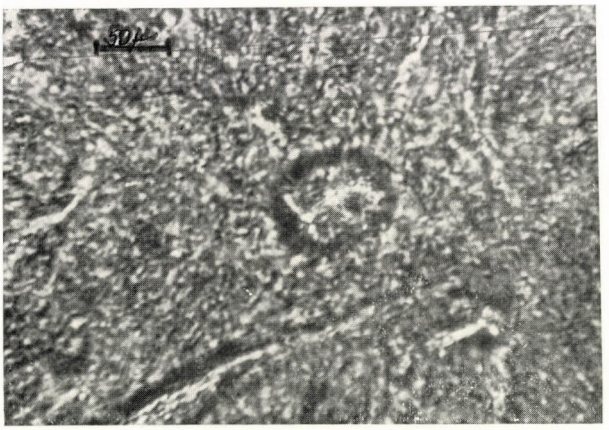

Fig. 7. Strong radioactivity detected in the glandular hair with four-celled head

The *Labiatae*-type large-headed glandular hairs (Fig. 8) reacted differently to histochemical reagents (to treatments with Sudan III (Fig. 9a, 9b), $KMnO_4$ (Fig. 10), Rosanilin-R (Figs 11 and 12), cc. H_2SO_4 vanillin (Fig. 13)). The difference is observable also between species. Isotope techniques confirm also this difference (Figs 14a, 14b).

Long-stemmed glandular hairs occur abundantly only in *Salvia sclarea* (Fig. 15). Histochemical reagents stained the head and neck cells of the

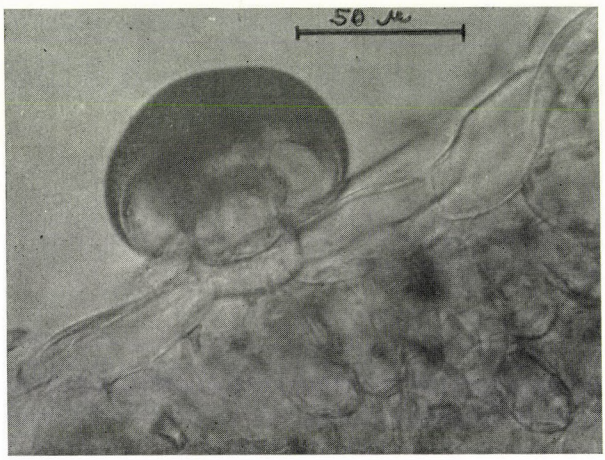

Fig. 8. Labiatae-type glandular hair in the untreated state of *Salvia officinalis*

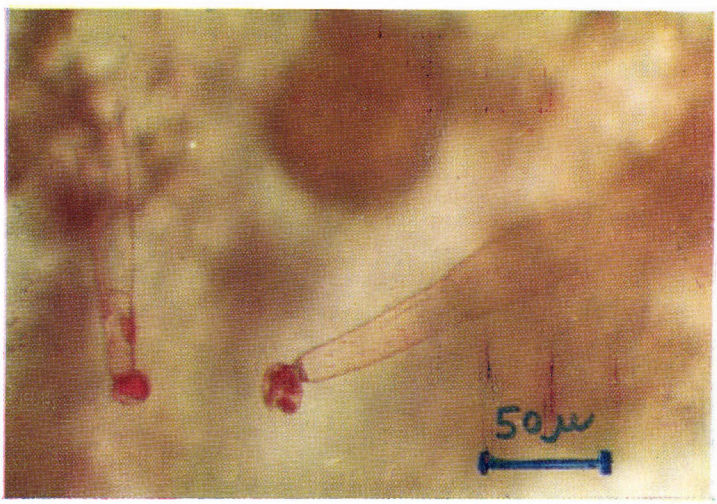

Fig. 9a. Salvia sclarea L. glandular hair (large-headed glandular hair with a long stem) stained with Sudan III

glandular hair in identical colours, for example, red-brown with Rosaniline (Fig. 9a); 2[14]C-Natriumacetate is also strongly localized in the neck and head cells where according to techniques evidence also transport processes occur.

Another type of trichomes is the covering trichome (Figs 16, 17), the plasm of which also displays activity, testfying on transport processes and special localization. Accordingly, also the covering trichomes secrete.

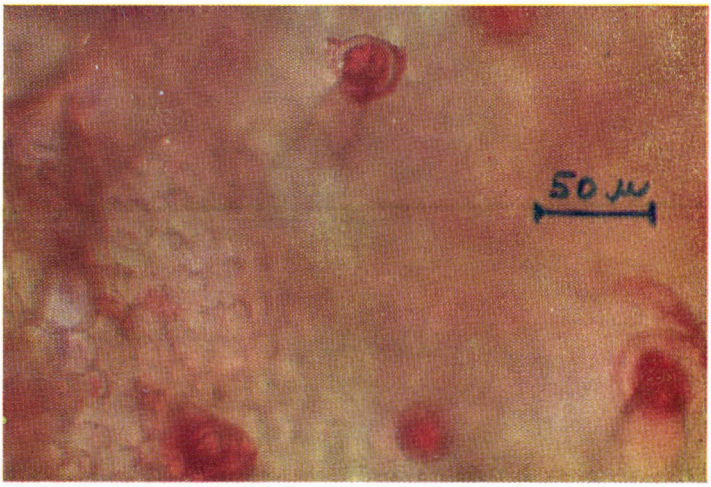

Fig. 9b. Types of glandular hair, characteristic of *Salvia officinalis*

Fig. 10. Salvia officionalis. Labiatae-type glandular hair stained with $KMnO_4$

Fig. 11. Large-headed glandular hair, stained with Rosanilin

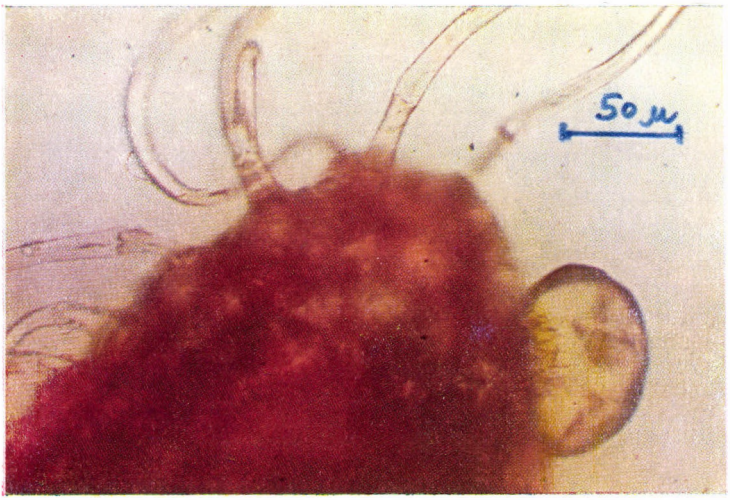

Fig. 12. Labiatae-type glandular hair of *Salvia officinalis* treated with Rosanilin

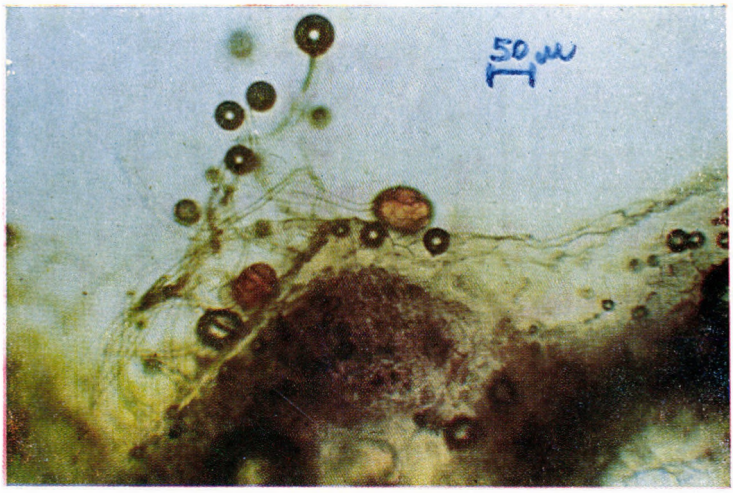

Fig. 13. Labiatae-type glandular hair treated with 1% cc. H_2SO_4

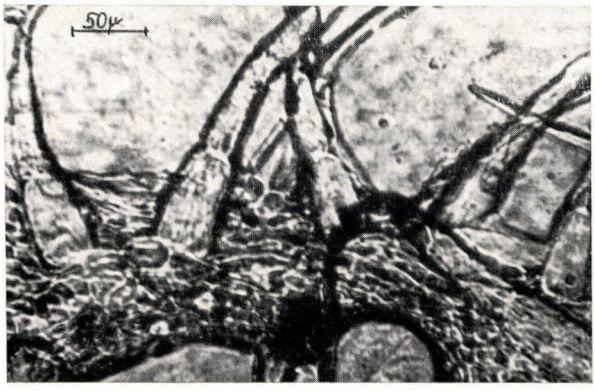

Fig. 14a. Radioactive *Labiatae*-type glandular hair after the absorption of 2^{14}C-Na-acetate, in *Salvia officinalis*

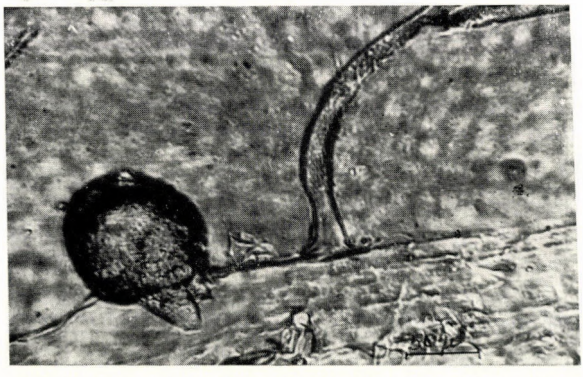

Fig. 14b. Inactive *Labiatae*-type glandular hair after the absorption of 2^{14}C Na-acetate, in *Salvia officinalis;* beside it, a radioactive small headed glandular hair

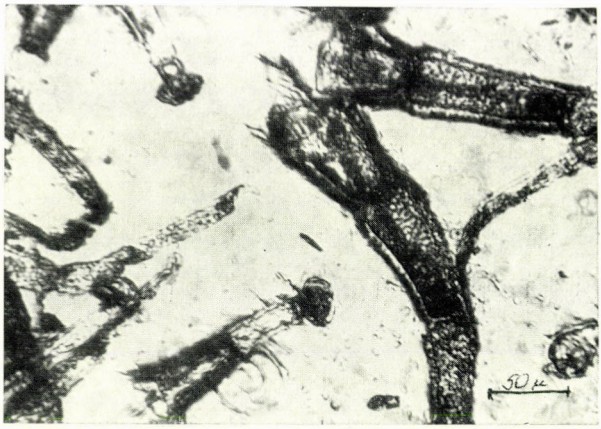

Fig. 15. Section of *Salvia sclarea* leaf after a treatment with isotope; M_1 = long-stemmed glandular hair; M_2 = *Labiatae*-type glandular hair; M_3 = glandular hair with two-celled head; F = covering trichome

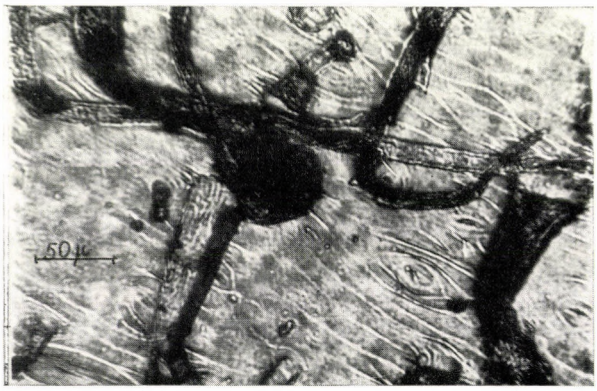

Fig. 16. Epidermal section of *Salvia sclarea* with stiff covering trichomes and various glandular hairs

Fig. 17. Characteristic, laniform trichomes in *Salvia officinalis*, after a 168-hour incubation with $2^{14}C$ Na-acetate

Summary

Subsequent to the absorption of a radioactive precursor, 2-^{14}C-natrium-acetate, the process of terpene formation and localization was investigated in the foliage leaf of two characteristic plants containing volatile oil, viz. *Salvia sclarea* and *Salvia officinalis*. On the basis of contact histoautoradiograms it could be established with the isotope infiltrates the terpene spectrum and stands out in the trichomes. In both species, the glandular hairs with two-celled head and those with four-celled head contain purer volatile oil than does the glandular hair with a monocellular head. Strong radioactivity is characteristic of the *Labiatae*-type glandular hairs with a large head. At the same time a functional difference is also observable among the glandular hairs of this type.

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UNREGELMÄSSIGE SPALTÖFFNUNGEN DER BLATTEPIDERMIS VON MAIS (ZEA MAYS L.)

Von

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In der Blattepidermis von bestrahlten Maispflanzen der Sorte »Fehér mazsola« sowie im epidermalen Gewebe von bestrahlten und von Kontrollindividuen der durch Inzucht erhaltenen Linie »WF 9« wurden verschiedene Stomadeformationen untersucht. Bei der Sorte »Fehér mazsola« wurden Stomaveränderungen nur an den mit Dosen von 3000 und 5000 R bestrahlten Pflanzen gefunden. Ihre Zahl und die Vielfalt der Stomaverformungen erreichte die der Individuen der durch Inzucht erhaltenen Linie »WF 9« nicht. Die deformierten Gebilde sind zunächst an den oberen Blättern entstanden; sie stehen mit anderen inneren (histologischen) oder äusseren morphologischen Deformationen in keinem Zusammenhang. Die Mehrzahl dieser Verformungen wurde bei anderen Pflanzengruppen bereits früher beschrieben, in der von uns untersuchten Literatur finden sich jedoch keine Angaben über die Familie *Gramineae*.

In der Blattepidermis durch Inzucht erhaltener und bestrahlter Maispflanzen wurden von uns verschiedene Spaltöffnungsabnormitäten gefunden. Ähnliche Verformungen wurden früher schon bei anderen Pflanzengruppen beschrieben, in der von uns untersuchten Literatur finden sich jedoch keine Publikationen über ähnliche Beobachtungen bei der Familie »Graminae» *(Poaceae)*. Da die auf verschiedene Ursachen zurückzuführenden unterschiedlichen Veränderungen in der Literatur unter dem Sammelbegriff »Stomaabnormität« dargestellt werden, muss vorweg ein Unterschied zwischen Degeneration und Deformation gemacht werden. Zum ersteren werden alle jene Erscheinungen gerechnet, bei denen die normal entwickelten Spaltöffnungen unter der Einwirkung äusserer Umstände (GUPTA et al., 1968; REHFOUS, 1920) oder aus genetischen Gründen (MAYNARD et al., 1974) verkümmern. MAYNARD et al. (1974) berichten von einem Extremfall, bei dem die Degeneration der Schliesszellen der entwickelten Spaltöffnungen zum völligen Absterben der jungen Pflanzen geführt hat.

Die von uns untersuchten Stomaveränderungen gehören zur Gruppe der Deformationen. So werden alle Erscheinungen bezeichnet, die durch abnormale Differenzierung der Spaltöffnungen entstehen. Die gehemmte Funktion der Meristemoide kann zum Beispiel das Fehlen einer der Schliess- oder der Nebenzellen zur Folge haben (PANT, MEHRA, 1965; GOPAL, SHAH, 1970), die Vermehrung der Schliess- und der Nebenzellen kann hingegen als Folge wiederholter Teilungen der Mutterzellen auftreten (GOPAL, SHAH, 1970). Es können weiterhin Verschiebung der Schliesszellen relativ zueinander, ferner ihre

Schrumpfung oder Vergrösserung (SLEPJAN, WASILJEW, 1974), das laterale bzw. polare Zusammenwachsen der benachbarten Spaltöffnungen (PANT, KIDWAI, 1966; GOPAL, SHAH, 1970), das Erscheinen von Zwillingstomata (SLEPJAN, WASILJEW, 1974; PRAT, 1948), usw. vorkommen.

Beachtenswert sind die Feststellungen von SLEPJAN und WASILJEW (1974). Nach ihrer Meinung entstehen die deformierten Stomata im allgemeinen in der Epidermis der teratologischen Organe. Sie haben erkannt, dass die Stomadeformationen bei den verschiedenen Pflanzenfamilien in nahezu gleichen Verformungen auftreten.

Material und Methode

Das Material unserer Untersuchung stammte aus einem mit der Maissorte »Fehér mazsola« *(Zea mays* L. convar. *saccharata)* und mit der durch Inzucht erhaltenen Linie »WF 9« angestellten Bestrahlungsversuch. Die Samen der Sorte »Fehér mazsola« waren Co^{60}-Bestrahlungen von 1000, 3000, 5000, 7000, 9000, 11 000 und 13 000 R ausgesetzt, die Dosen bei Individuen der durch Inzucht erhaltenen Linie »WF 9« beliefen sich auf 500, 1500, 4500, 13 500 und 18 000 R. Die Untersuchungen wurden je Variante an drei Pflanzen sowohl an der Ober- als auch an der Unterseite des von oben gerechnet ersten, vierten und achten Blattes durchgeführt. Bekanntlich gibt es an der Blattunterseite mehr Spaltöffnungen als an der Oberseite (WOLCSÁNSZKY—MOLNÁROS, 1964). Spaltöffnungen treten auch bei den oberen Blättern häufiger als bei den unteren auf (ZALENSKY, 1904; MAKSIMOW, 1957). Bekannt ist schliesslich auch, dass sich das Tempo der Stomadifferenzierung nach den oberen Blättern hin allmählich verlangsamt (SCHÜRMANN, 1959; PISEK et al., 1970). Durch den Vergleich der Blätter verschiedener Höhenlage konnten wir zugleich Aufschluss über die in den verschiedenen Stadien der Ontogenese auftretenden Abnormitäten und auch über die Topographie der Deformationen in der Epidermis erhalten.

Bei den gesäuberten und durchleuchteten Blattstücken untersuchten wir die Zahl und Grösse der Hautgewebeelemente, wobei wir die abnormal geformten Spaltöffnungen abzeichneten und photographierten.

Die Ergebnisse der Untersuchungen

Die am häufigsten auftretenden Spaltöffnungsabnormitäten werden durch die Zeichnungen (Abb. 1 und photographischen Aufnahmen (Abb. 2) veranschaulicht.

Auffällig ist die Erscheinung, dass die Schliesszellen dreier Stomata in Längsrichtung zusammenstossen (Abb. 1: 1, 3, 5; Abb. 2: 8). Die Schliesszellen

sind deutlich gesondert, die Nebenzellen dagegen fliessen mehr oder weniger ineinander. Manchmal sind die zweiseitigen Nebenzellen an der Spitze der Spaltöffnung miteinander durch ein mützenförmiges Gebilde verknüpft (Abb. 1: 6, 7; Abb. 2: 10). In einem anderen Falle stehen zwei Stomata miteinander in polarer Berührung, hier aber sind sowohl die Schliesszellen als auch die Nebenzellen voneinander getrennt (Abb. 1: 2; Abb. 2: 9). Es kommt ferner vor, dass zwischen den Stomata zweier benachbarter Reihen durch die Nebenzellen eine Verbindung entsteht (Abb. 1: 4; Abb. 2: 11, 12). Die Nebenzelle der Spaltöffnung in der einen Reihe greift — vergrössert — schräg in die benachbarte Reihe über und schliesst sich an die Nebenzelle des anderen Stoma an.

Während unserer Untersuchungen haben wir auch die beim Mais schon bekannten »Zwillingsstomata« gefunden, die bei der Verbindung zweier Epidermiszellenreihen vorkommen (Abb. 2: 11, 13).

Bei der Sorte »Fehér mazsola« wurden abnormal gebildete Spaltöffnungen nur an den bestrahlten Pflanzen (3000, 5000 R) beobachtet, bei Individuen

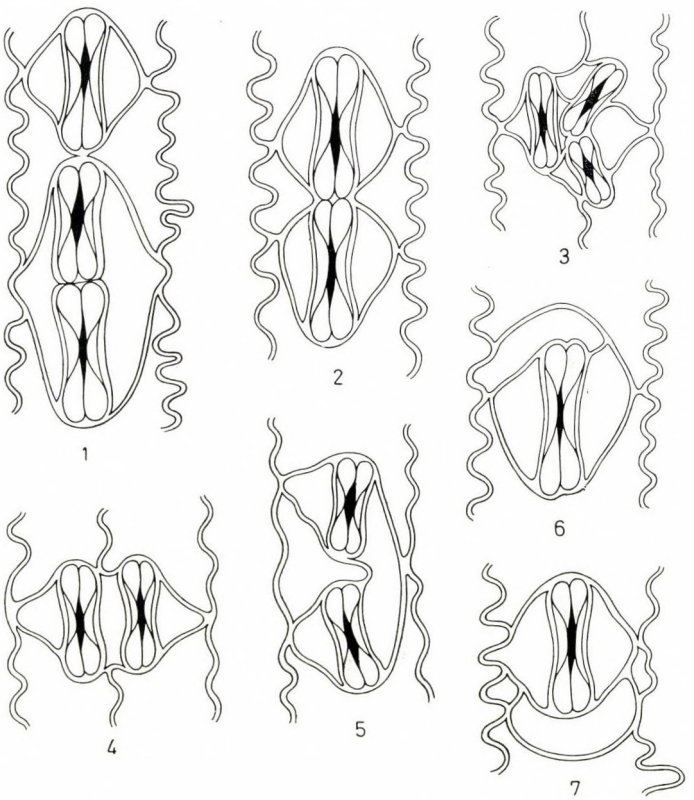

Abb. 1. Abnorme Spaltöffnungen der Blattepidermis von Individuen der durch Inzucht erhaltenen Linie »WF 9« (1—7).

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Abb. 2. Abnorme Spaltöffnungen der Blattepidermis von Pflanzen der Sorte »Fehér mazsola« (*Zea mays* L. convar. *saccharata*) nach Bestrahlung mit dem Kobaltisotop Co^{60} (8—13)

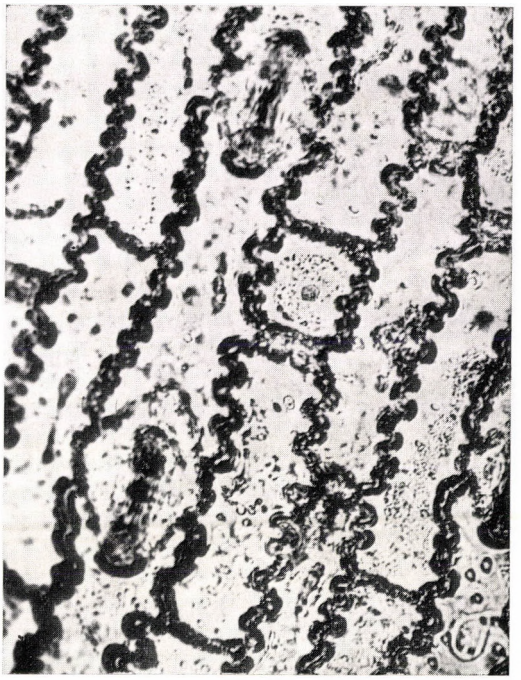

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Abb. 2. Fortsetzung.

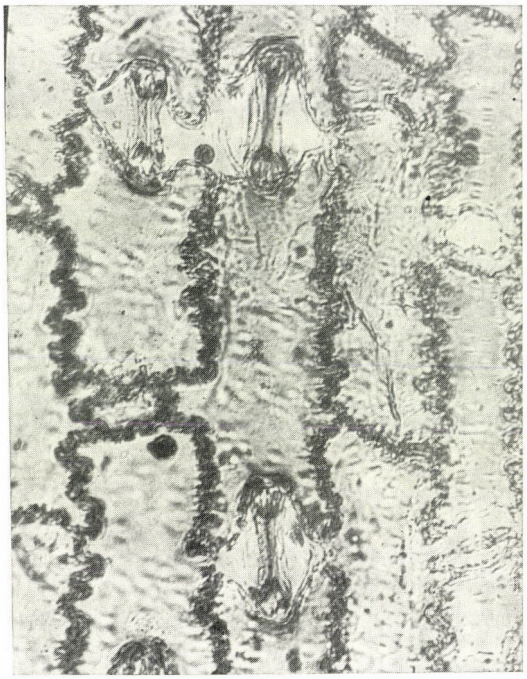

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Abb. 2. Fortsetzung.

der durch Inzucht erhaltenen Linie »WF 9« jedoch auch an den Kontrollpflanzen. Es wurde ferner festgestellt, dass die Zahl und die Vielfalt der Stomaverformungen bei der durch Inzucht erhaltenen Linie die der Sorte »Fehér mazsola« bei weitem übertrifft.

An den von uns untersuchten Pflanzen lagen die deformierten Stomata im Hautgewebe normal entwickelter Organe. An den oberen Blättern haben sich mehr abnormale Spaltöffnungen differenziert als an den unteren. Am Aufbau der einzelnen abnormalen »Stomakomplexe« sind höchstens drei Spaltöffnungen beteiligt. Die Stomata sind voneinander in jedem Falle durch Zellwände getrennt, während die Nebenzellen im allgemeinen unterschiedlich stark ineinanderfliessen.

Diskussion der Ergebnisse

Unsere Beobachtungen über Stomadeformationen lassen auf eine Hemmung, wenn nicht auf eine vervielfachte Teilung der Meristemoide schliessen. Die ungeregelte Anordnung der Stomata stört die für die Süssgräser so charakteristische Ordnung der Hautgewebeelemente.

Die Feststellung von SLEPJAN und WASILJEW (1974), nach der die Stomaabnormitäten bei den Pflanzen der verschiedenen Systematikgruppen auf ähnliche Weise, mit gleichen Deformationen auftreten, können wir um so mehr bestätigen, als auch wir an Hautgewebe des Maises die schon bei anderen Familien beschriebenen Veränderungen vorgefunden haben. Wir beobachteten höchstens aus drei Stomata gebildete abnormale »Komplexe«, was mit den von anderen Autoren veröffentlichten Feststellungen und Abbildungen übereinstimmt.

Dagegen können wir die Auffassung SLEPJANS und WASILJEWS (1974) von der Korrelation zwischen deformierten Stomata und Organen bzw. Geweben nicht belegen. An den Blättern und in den Geweben der untersuchten Maispflanzen haben wir keine andere abnormale Änderungen beobachtet.

Die Tatsache, dass die Mehrzahl der unregelmässigen Spaltöffnungen im Hautgewebe der oberen Blätter entsteht, kann einesteils mit dem Gesetz von ZALENSKY (1904) erklärt werden. Nach diesem Gesetz gibt es bei den oberen Blättern mehr Spaltöffnungen als bei den unteren, und somit können an jenen — nach einer einfachen statistischen Gesetzmässigkeit — auch mehr Abnormitäten entstehen. Andererseits kann auch die bei den oberen Blättern beobachtete Verlangsamung des Teilungstempos der Meristemoide daran beteiligt sein, so dass die die Deformierung beeinflussenden und durch Stoffwechsel zur Geltung kommenden Faktoren längere Zeit wirken.

Die grosse Zahl und der Formenreichtum der Deformationen bei Individuen der durch Inzucht erhaltenen Linie »WF 9« sind vermutlich der genetischen Labilität dieser Pflanzen zuzuschreiben.

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RECENSIONES

Á. Boros (†)—M. Járai-Komlódi: An atlas of recent European moss spores, 1975, 466 pp. 237 plates. Akadémiai Kiadó, Budapest

Hungarian literature on the subjects of bryology and palynology has been significantly enriched by a book the first to be published since Erdtman's-offering a detailed and comprehensive description of living moss spores. It is rightly expected that it will command interest among professionals in Europe as well as in other parts of the world.

The section on bryology was compiled by A. Boros, acquainting public with the last significant contribution of the author, deceased in 1973. The section dealing with palynology is the work of the well-known Hungarian palynologist, M. Járai-Komlódi.

The purpose of the authors is twofold. They wish to call attention to the role which moss spores play in palynological research, because the full significance of moss spores still have not been realized despite the fact that they readily fossilize in deposits of various ages. At the same time, it is well known that mosses are among the oldest plants and that many species adhere to unusual ecological features, thus they are often found in biotops apt for fossilization, and therefore the determination of moss species on the basis of spores can give precise information about ecological conditions in which spores become fossilized.

All this confirms that "the knowledge of moss spores and the determination of plants producing them cannot be ignored by paleobotanists either from the viewpoint of phylogenetics or from vegetation history".

A further object of this work is to contribute to the solution of certain systematic and taxonomic problems in the light of available knowledge on moss spores.

The book is divided into two major parts. In the first part an introduction to the purpose of the book is given with respect to bryology and palynology; the method of spore preparation is described together with detailed account of the morphological features of spores which have been utilized during the investigations. A list of pertinent literature closes this section.

The second part considers, per species, the special question of moss distribution, ecology, the frequency of spore formation, spore morphology, within it the dimensions, shape, structure and ornamentation of the spore, the number of chromosomes characteristic to each species and herbarial data on locality and time of collection, name of the field worker, the year in which collection was made, and the reference number by which the utilized and marked specimen is indicated in the botanical collection of the Natural History Museum, Budapest.

In this part of the book the authors deal with 235 living moss species which have been selected to represent all European families and genera characterizing the circumboreal area. Relict species living in torfmoors or moorlands are represented in greater number. Similarly, the authors have selected species which produce spores copiously but are not to

be found in moorlands, and mosses whose spore production is in recent times small and an infrequent phenomenon. The latter have probably spores more abundantly in the geological past.

Spores of xerophilous mosses living on rock and rinds are also covered, although these spores as a rule do not fossilize. But the atlas was intended to give assistance not only to researchers in palynology but also in taxonomy.

The description of each species is supplemented with 10 to 15, in some instances with even more, high-quality microscopic photographs. In the case of 12 species, pictures taken by the scanning electron microscope are submitted. In order to aid identification of a given species, drawings depicting the characteristic ornamentation of spore walls are supplied or, as in the case of hepatics, photographs illustrate the elater structure.

A subject index compiled with great care completes the book. The discussion of the spores of 235 moss species is supplemented by finely executed photographic material which can be advantageously used in paleobotanical, bryological and taxonomical research. The book should be well received by bryologists and palynologists as well in Hungary as abroad.

S. Orbán

G. Reichert: Die methodischen Voraussetzungen für eine Kultur höherer Pflanzen unter kontrollierten und reproduzierbaren Bedingungen. Westdeutscher Verlag, Opladen 1973, 32 pp.

The paper published in the series "Forschungsberichte des Landes Nordrhein-Westfalen", No. 2267, gives the particulars of a small-sized phytotron devised by the author. The carefully designed and constructed instrument makes research work possible, with a great degree of precision in ecology and biology with respect to vascular plants under controlled environment.

The adjustable temperature range is between —20°C and +40°C, with ±0.1°C accuracy. Moisture content, depending on the prevailing temperature, can be regulated between 30 to 95%. Maximum power of illumination is 25 000 Lux.

The instrument also ensures the adjustability of the carbon dioxide concentration from 0.01% to 3.00%; the velocity of air flow and the exchange of air can also be regulated.

The detailed account will be a significant aid for all those who are engaged in the design and construction of phytotrons.

I. Horváth

Limnology of Shallow Waters (Editors J. Salánki and J. E. Ponyi). 1975, 304 pp. No. 15. Symposia Biologica Hungarica. Akadémiai Kiadó, Budapest

This volume contains the full text and figures of the 29 papers presented at the symposium "Limnology of Shallow Waters". This meeting, sponsored by the Department of Biology of the Hungarian Academy of Sciences and organised by the Research Institute of Biology (Tihany), was held in September, 1973.

During congresses of the International Limnological Society (SIL) and at international hydrobiological meetings the demand was emphasized several times to organise a special meeting dealing entirely with problems of shallow waters, to bring the experts of this field under a common roof. It has been a well-established and lucky idea to organize this

meeting in Hungary, in a country where real "deep and stratified lakes" (according to the classical limnological definition) do not exist (all Hungarian lakes are shallow waters of the Pannonian type). Finally, the Symposium was organized in Tihany, at the shore of Lake Balaton, the lake which is not only shallow and the largest in Central Europe, but at the same time studied most extensively and for the longest time.

The topic of the Symposium was of great importance not only for hydrobiologists, but concurrently for all biologists studying environmental problems. The problems of natural and artificial human environments are justly in the lime-light of our times and their study is emphasized by a number of international scientific research programmes.

One of these programs is MAB (Man and Biosphere), sponsored by the UNESCO. This program is global and regional, governmental and scientific at the same time. Topic 5 of this program "Ecologic effects of human activity on the values and resources of lakes, moors, rivers, deltas, estuaries and costal zones" is of central importance. One of the Main Activity Directions, initiated by the Hungarian Academy of Sciences, "Protection of the Natural Environment of Man" is closely connected to the MAB program. The papers presented during the Symposium were partly elaborated within the framework of the IBP.

The frightening deterioration of our natural environment and the general pollution endanger shallow waters to a high extent; this means that the symposium had a special actuality.

Papers centered on two main topics: 1. primary and 2. secondary production; as the readers of Acta Botanica are interested primarily in the first topic, these will be summarized in more detail.

Bacterial production and decomposition, esp. its seasonal dynamics in the water and sediments of Lake Fertő, were studied by M. Dokulil. The activity of the bacterial microflora in seven of the eutrophised Masur Lakes was studied by W. A. Goldlewska-Lipowa.

Six papers deal with the primary production of the phytoplankton. The illumination, composition, biomass and production of phytoplankton were determined in Lake Balaton at several depths during a whole year by S. Herodek and G. Tamás. The dead arm of the Danube at Tolna, and the sodic waters so characteristic to the Hungarian Lowland, were studied from the point of gross and net primary production by S. T. Dvihally. Primary production data of the small oligotrophic lakes in Terra Nova National Park (Newfoundland) are quoted by chlorophyll measurements in the paper by J. J. Kerekes (Canada); and the seasonal variations of the primary production of *Gomphonema* and *Ulothrix* algae, which sometimes proliferate in the water of Lake Tahoe (California-Nevada, USA), are discussed in the paper by Ch. R. Goldman and E. Amezaga. I. Spodniewska studied the effect of deliberately altered fish stock upon composition, biomass and production of phytoplankton in the Warniak fish pond (Poland). The qualitative and quantitative analysis as well as the estimation of biomass of phytoplankton in dammed lakes of the Mts. Mecsek are described in the paper by A. Kovács, L. Vörös and G. Uherkovich.

Four papers deal with the production of the higher aquatic plants. I. Kárpáti and V. Kárpáti used air mapping of weed stock and weed production. Phenology and growth characteristics of duckweed (*Lemna gibba* L.) was investigated in a Pannonian fishpond in Czechoslovakia by E. Rejmanková; and an invasion stand of *Typha latifolia* L., occuring on flooded arable soil at the former Lake of Kobyli, S. Moravia (Czechoslovakia), was studied for the seasonal changes in shoot biomass and the contents of essential mineral nutrients by J. Kvet. In a detailed study of high informative value, by J. Komárková and J. Komárek, the primary production of phytoplankton in water and periphyton adhered to the stems of various macrophyte populations in a fishpond in S. Bohemia (Czechoslovakia) are discussed.

Some papers approach production from the chemical side. R. Schröder describes the phosphorus regime of the Bodensee, J. Oláh extrapolates the role of the metalimnion

in production biology upon the sediments of shallow waters. E. DONÁSZY gives an account of the studies of the Szelidi-tó; this lake in Hungary is typically sodic, and its investigation has the added value that an almost continuous series of data, covering 30 years, are available. B. T. HARGRAVE writes on the importance of depth and intermixing in the supply of organic substances to bottom communities.

Papers on secondary production discuss results of zoological studies of shallow lakes of various hydrographical conditions in Europe (Balaton, Fertő- and Velence lakes in Hungary, lakes in Bulgaria, Yugoslavia, GFR) and alpine lakes in Canada with primary emphasis on biomass survey, production and food utilisation.

The editors of this finely presented volume endeavoured with success to render an uniform outlook to text and figures; however, a more detailed subdivision of papers would have been justified. The thoroughly cross-indexed subject index adds to the versatility of the volume.

Hydrobiology is a branch of science which considering demands has been neglected in Hungary; thus the publication of this valuable book for scientists in Hungary and abroad is a most welcome fact, deserving full credit for editors and publisher.

S. T. DVIHALLY

H. WALTER: Die Vegetation der Erde in öko-physiologischer Betrachtung. I. Die tropischen und subtropischen Zonen. 3rd ed., Jena, VEV FISCHER, 1973, pp. 743.

This monumental book, describing the vegetation of the Earth on a causal-ecological basis, which I reviewed in Acta Bot. Acad. Sci. Hung. 15:204—205, and in Bot. Közl. 56:56 (1969), has achieved such a great success that its volume analysing the vegetation of tropical and subtropical zones has been published in English (Ecology of Tropical and Subtropical Vegetation, Edinburgh, 1971), as well as in Russian, while there is now a third German edition. I must call attention to the latter, since it has been completely revised. The introductory part, which discusses the fundamental notions and also questions concerning the biosphere, ecosystem, potential phytomass, and the primary product is shorter here, while the detailed elaboration has been enlarged. This is divided into three main chapters: 1. the vegetation of the equatorial zone; 2. that of the zone of tropical summer rains; 3. that of the subtropical arid zones. Rain woods are discussed in Part 1; semi-evergreen and deciduous woods as well as savannah, in Part 2; and deserts (the author knows all these from personal experience) are treated in Part 3. A considerable part in the analysis is played by climate diagrams and climatograms. (As is known, these terms have also been introduced by WALTER.) In the near future, an atlas of the ecological climatic division of the earth will be published (by G. FISCHER, Stuttgart) in a separate volume, with 9 great climate diagram maps.

Vegetation der Erde has also been published as a university textbook edition entitled "Vegetationszonen und Klima", 1970, 2nd ed. in 1973; the same in English in 1973. — The complete vegetation geography, in the classical division of four parts, viz. that of floral, historical, cenological and ecological divisions, entitled "Allgemeine Geobotanik" was published by ULMER, Stuttgart, 1973, 256 pp. — I recommend the latter, relatively cheap edition to our younger fellow researchers.

R. Soó

HARTMANN, F. K. (ed.): Ökologie der Wälder und Landschaften. — Volume 3: MAYER, H.: Wälder des Ostalpenraumes. Stuttgart, G. FISCHER, 1974; 344 pp., 63 illustrations, 130 DM.

Two volumes of this series edited by a late friend of mine, the great forester-botanist HARTMANN, have already been reviewed (Soó: Bot. Közl. 54: 184, 1967; Acta Bot. Acad. Sci. Hung. 14: 445, 1968; BORHIDI: Acta, l. c. 18: 436—437, 1973). — The new volume has been written by HANNES MAYER, the leading figure of the Viennese forester-botanists. As the area of the Eastern Alps extends from Switzerland to our country, the volume on ranges of the Eastern Alps closely interests us too. The author and his school characterizes by using 50 sociological-ecological species groups; the character-species and system of the BRAUN-BLANQUET school are disregarded; their nomenclature, and occasionally their meanings too, are identical with already described associations; authors' names are occasionally given, without regard to priority. No detailed tables are included, but the tree species combinations and the correlations between species groups in the various associations and subassociations are demonstrated in suitable drawings (these are subsequently called tables).

The chapter titles, demonstrating the author's system are as follows: 1. larch- cembra pine woods (the subalpine ligneous associations are also discussed here); 2. natural spruce woods (a: subalpine, b: montane, c: ex-Alpine woods); 3. silver fir woods (spruce-silver firs and spruce-silver fir-beeches); 4. beech woods (in co-operation with K. ZUKRIEGL; 9 associations); 5. forests rich in oak (oakwoods with hornbeam, acidophilous and basiphilous oakwoods, up to the evergreen *qu. ilex* forests; 11 associations); 6. mixed forests (a very mixed group: wood of maple, ash, alder; thus partly rock forests, partly fens and marsh woods; 11 associations); 7. pine-woods (the heterogenous, both ecologically and cenologically, associations of mountain, Scots(common) and Austrian pines); 8. marshy woods (several associations, with the pioneer associations); 9. culture forests (derivated associations). — Forest-economy viewpoints of practice are in the forefront in each chapter. The forest history of the region, the development of the important tree species areas, and the connection between man and forest are written by F. KRA). — The last chapter provides the forestry-geographical division of the Eastern-Alps forest zones and growth regions ("Wuchsbezirk"). Although it is not mentioned, the Hungarian Alpine peaks belong to the mixed-oak forest zone of the Eastern "Alpenvorland". — Of the Hungarian literature, certain works of CSAPODY, JAKUCS, MAJER, PÓCS, SOÓ and ZÓLYOMI are cited but little used. It is not easy, therefore, to state how the associations described by the Hungarian authors according to the principle of the BRAUN-BL. school are in agreement with the items of nomenclature (about 300 altogether) given by MAYER and co-workers. It is mainly the books of the Austrian MAYER and the Hungarian MAJER that can be compared. — On the other hand, from the viewpoints of forestry, sylviculture, renovation, afforestain, nature conservancy, etc. the work is an excellent summary.

R. Soó

HARTMANN, F. K.: Mitteleuropäische Wälder. Ökologie der Wälder und Landschaften. — Vol. 5., Stuttgart, G. FISCHER, 215 pp., 212 illustrations, 84 DM.

This work, which is the last by the late F. K. HARTMANN, is the illustration book, the supplement to the first volume. The illustrations partly consist of photographs taken of associations or plants, and partly of drawings which show the character and structural building of the forest associations. The text presents the concise characterization, characteristic species, distribution and varieties of the forests in the Central-European Ranges of Mountains of medium height. A great majority of these are similar in ecology and composition to their Hun-

garian counterpart, but they are not identical. The drawings and pictures where the various species are denoted by numbers and the captions are keys to them are very instructive. — The bibliography includes appropriately selected items (from the Hungarian authors JAKUCS, SOÓ, ZÓLYOMI), and there are several lists of terminology.

It is indeed a great pity that Professor HARTMANN does not live to see the publication of this book which crowns with success his life's work.

R. Soó

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S. Jávorka — V. Csapody

Iconographia Florae Partis Austro-Orientalis Europae Centralis

Collaborators: R. Soó and Sz. Priszter
Edited by Szaniszló Priszter

ICONOGRAPHIA is a new edition of the work published in paperback series between 1929 and 1934. The collection of drawings is essentially unchanged, the introductory text has been revised and brought up-to-date. The volume is a virtual masterpiece containing the true-to-life drawings (and paintings) of over 4000 plant species of the Pannonian and Carpathian, and partly of the Illyrian and Mediterranean flora. The volume will be almost indispensable aid in the identification of plants in that no similar work is available. – *Rezső Soó* has compiled a large chapter of the changes in nomenclature, thereby bringing it completely up-to-date. *Szaniszló Priszter* furnishes a detailed explanation concerning the bibliographical implications that were not known in the first edition; he also compiled a list of abbreviations and one of geographical names which have, in many cases, changed. Finally, in order to facilitate the use of this source work, he provides a detailed Hungarian-Latin-English dictionary of all technical terms used in the figure captions. – The volume is completed with an index of Latin generic names.

Introductory text in Latin and English, with a supplement in Hungarian · Approx. 740 pages · Illustrations of 4090 plants · 40 colour plates · 17 × 25 cm · Cloth · ISBN 963 05 0502 9

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РЕЗЮМЕ

ИЗУЧЕНИЕ КРАХМАЛЬНЫХ ЗЕРЕН С ПОМОЩЬЮ УЛЬТРАФИОЛЕТОВОЙ ФЛЮОРЕСЦЕНТНОЙ МИКРОСКОПИИ В ТОЧКЕ РОСТА ЯБЛОНИ, БЕЗ И ПОСЛЕ ПРИМЕНЕНИЯ МОРФАКТИНА

Т. БУБАН и О. ЦЕЛЛЕР

В прежней работе авторы выявили присутствие крахмальных зерен в субапикальных удлиняющихся тканях растущих точек роста побегов и в базальной части самых молодых зачатков листьев, расположенных возле конуса нарастания.

Распределение крахмальных зерен в клетках тканей точки роста побега не связано ни с вертикальным или горизонтальным положением побега, ни с применением морфактина, понижающего геотропическую чувствительность.

При флюоресцентной микроскопии в значительной мере повышена специфичность альциан-блу 8 — метайодная кислота — Шиффового реактива (AB—PAS).

ИЗУЧЕНИЕ ИНТЕНСИВНОСТИ ОСВЕЩЕНИЯ В БУКОВЫХ ЛЕСАХ РАЗЛИЧНОГО ВОЗРАСТА

М. ДРАШКОВИЧ

В трех буковых лесах различных возрастных классов на уровне дерна, а также на вблизи расположенной поляне были проведены синхронные фотоэлектрические измерения света с помощью люксметра в отдельных категориях высоты солнца, повторность была равна 32. Целью работы было показать, какой изменчивости освещения подвержены виды растений, произрастающие в поросли трех возрастных классов с различной структурой насаждения. Относительно освещенности насаждений различного возраста наименьшие различия были выявлены в период полного развития листвы. В переходный вегетационный период — процесс облиствения — наблюдаются значительные различия в освещении. В молодом и старом насаждениях в безлистном состоянии структура стволов и ветвей обусловливала сходные условия освещения, тогда как в насаждениях среднего и старого возраста структура листвы привела к сходным условиям освещения.

ИЗМЕНЕНИЯ ПОВЕРХНОСТИ И ВЕСА СВЕТОВЫХ И ТЕНЕВЫХ ЛИСТЬЕВ И ПОБЕГОВ QUERCUS PETRAEA И QUERCUS CERRIS В ЛЕСНОЙ ЭКОСИСТЕМЕ ВЕНГРИИ

П. ЯКУЧ и К. ВИРАГ

На двух древесных породах: *Quercus petraea* и *Quercus cerris*, произрастающих на территории «Шикфёкут проект», предназначенной для изучения экосистем, авторы проводили исследования роста световых и теневых листьев и побегов. Результаты приводятся в пересчете на поверхность и на сухой вес листьев и относятся к 1973 году. На основе световопланиметрических данных и данных сухого веса, собранных ежемесячно или на каждой второй неделе, можно было проследить динамику продукции листьев и побегов, а также потерю веществ, вызванную объеданием листьев гусеницами. Приводятся данные также числа листьев в пересчете на гектар.

ИЗМЕНЕНИЕ РАЗВИТИЯ ПОЧЕК У СМОРОДИНЫ ПРИ ЗАРАЖЕНИИ CECIDOPHYOPSIS RIBIS WESTW.

Б. КАУСМАНН и У. ФОККЕ

У смородины (*Ribes* sp.) почки следующего года появляются уже весной. После вегетативной фазы (развитие почечных чешуек и зачатков листьев), верхушка побега может превратиться в соцветие. При заражении *Cecidophyopsis ribis* WESTW. нарушается развитие почек и не происходит образования листьев и соцветий. В работе дается описание гистогенетических деформаций прото- и субпротодермы и обсуждаются причины этого явления.

ПРИМЕНЕНИЕ СКАНИРУЮЩЕЙ ЭЛЕКТРОННОЙ МИКРОСКОПИИ У ИСКОПАЕМЫХ РАСТЕНИЙ

М. КЕДВЕШ и М. РАДВАНСКИ

С помощью сканирующего микроскопа SM-50A Jeol были проведены исследования на ископаемых растениях видов *Pleurozonaria concinna, Ovoidites ligneolus* и двух видов рода *Oculopollis*. Было установлено, что снимки сильного увеличения (150 000 ×) предоставляют важные новые данные о тонкой структуре поверхности. Субмикроскопическая скульптура двух видов *Normapolles* с глазками из слоев верхнего мелового периода одинакова. Следовательно это по всей вероятности является экологическим свойством, а не специфической для вида особенностью. Исследовавшиеся виды *Normapolles* с глазками на основе тонких поверхностных образований, принимая во внимание сообщение Сривастава (1972 г.), отличаются от видов *Trudopollis*. По исследованным видам были получены также данные о подробностях отложения в течение фоссилизации.

КРИОБИОЛОГИЧЕСКИЕ ИССЛЕДОВАНИЯ В ГОРАХ ВЫСОКИЕ ТАТРЫ

Е. КОЛ

В горах Высокие Татры известны микроорганизмы следующих окрашиваний криосестона: красный снег с *Chlamydomonas nivalis, Chlamydomonas sanguinea;* желтый снег с *Chlamydomonas flavovirens, Chlamydomonas rostafinskii;* желтобурый снег с *Chromulina ettlii* и зеленый снег с *Koliella tatrae* и *Carteria gyoerffyi*. Снежная растительность Высоких Татр относится к III-у типу верхней криовегетации.

В горах Высокие Татры в последние годы в области криобиологических исследований наблюдается новый подъем. Е. Кол проводила измерения pH снега. Хиндак, Яворницки и Комарек проводили приэкологические и криобиологические исследования, а также количественные и оптические (фотосинтез) измерения. Исследователям Хиндак и Яворницки удалось культивировать криоводоросли и выращивать чистые культуры.

РАСПРЕДЕЛЕНИЕ И ДИНАМИКА СОДЕРЖАНИЯ ФОСФОРА, АЗОТА И КАЛИЯ В МНОГОЛЕТНЕМ ОТКРЫТОМ ПЕСЧАНОМ ДЕРНЕ (FESTUCETUM VAGINATAE DANUBIALE)

ЭДИТ КОВАЧ-ЛАНГ

В многолетнем открытом песчаном дерне — *Festucetum vaginatae danubiale* —, являющемся общераспространенным и характерным для песчаных почв в междуречье Дуная и Тисы, изучались — параллельно с сезонной динамикой фитомассы — распределение и динамика содержания фосфора, азота и калия в отдельных фракциях фитомассы и в почве. В 1971-ом году ежемесячно анализировали растительный материал 22 монолитов размером в 20×20×20 см.

Было установлено, что в отдельных фракциях фитомассы наиболее высокой является концентрация азота, концентрация калия несколько ниже, в то время как концентра-

ция фосфора примерно на один порядок величины меньше концентрации азота и калия. При наиболее высокой концентрации все три элемента были выявлены в живых частях растений. Концентрация азота понижается в следующем порядке: живые надпочвенные части, мертвые надпочвенные части, корни. В случае калия и фосфора концентрация понижается по порядку: живые надпочвенные части, корни, мертвые надпочвенные части.

В почве концентрация трех элементов намного ниже. Большинство питательных веществ, накопившихся в фитомассе, находится в почвенных частях. На территории в 1 га вся фитомасса многолетнего открытого дерна содержит примерно 100 кг азота, 30 кг калия и 7—8 кг фосфора. На территории в 1 га в соответствующем почвенном слое мощности в 20 см общее содержание азота составляет примерно 1000—2000 кг, содержание общего калия — 3000—3200 кг, а содержание общего фосфора — 300—500 кг. Из этого запаса усваиваемое количество составляет примерно 12 кг азота, 150 кг калия и 30 кг фосфора.

В изученной системе почва-растение под биологическим контролем находится меняющаяся доля элементов, а именно 10% общего азота, 3% калия и примерно 1% фосфора.

Соотношение запаса усваиваемых элементов и накопившихся в фитомассе запасов указывает в случае азота на то, что количество усваиваемого азота в почве в качестве фактора минимума может ограничить количество азота, встраиваемого в органическое вещество и, следовательно, и саму продукцию.

ОБЗОР РАБОТ ПО ИЗУЧЕНИЮ ПРОДУКЦИИ ТРАВЯНИСТЫХ РАСТЕНИЙ В ВЕНГРИИ

Э. МОЛЬНАР

В статье дается подытоживающий обзор работ по изучению урожая лугов и пастбищ, проводившихся венгерскими ботаниками. Измерения осуществлялись на территории 60 поселений страны. На основе публикаций, появившихся до 1975 года, сообщаются названия растительных сообществ, применяемых отдельными авторами, результаты измерения урожая 32 растительных сообществ (при единообразном исчислении г/м²), а также имена авторов.

Наибольший урожай был получен в сообществе: *Scirpo-Phragmitetum glycerietosum.*

ИССЛЕДОВАНИЕ СТРУКТУРЫ ВНЕШНЕЙ ПОВЕРХНОСТИ НАРУЖНЫХ ОБОЛОЧЕК ЭПИДЕРМИСА КОРНЕЙ ПШЕНИЦЫ И КУКУРУЗЫ С ПОМОЩЬЮ СКАНИРУЮЩЕЙ ЭЛЕКТРОННОЙ МИКРОСКОПИИ

Н. Г. ПОТАПОВ, В. Н. ФИЛИППЕНКО, Л. Г. КОСУЛИНА

С помощью сканирующего электронного микроскопа изучали внешнюю поверхность корней пшеницы и кукурузы. Выявлена неоднородность поверхности корней. Отмечается увеличение плотности структурных элементов внешней поверхности как корневых волосков, так и корней в целом в базипетальном направлении. Корни покрыты слизистой оболочкой. Кроме того, слизь обнаруживается в виде локальных скоплений и глобул, которые наиболее часто встречаются в зоне вблизи корневого чехлика и зоне корневых волосков. В местах разрыва непрерывного слоя слизи на поверхности наружных клеточных оболочек зон растяжения и дифференциации в плотном, аморфном матриксе выявляются профили фибриллярной структуры. При развитии корневых волосков трихобластами корней пшеницы наблюдался разрыв внешнего слоя клеточной оболочки. Предполагается, что последний представляет собой разрыв слизистой оболочки, кутикулы и прилегающего слоя аморфного матрикса с включенными в нем, беспорядочно разбросанными волокнами. У корней кукурузы четкой картины разрыва внешнего слоя оболочки не обнаружено. Поверхность корневого волоска также неоднородна. Кончик волоска покрыт своеобразной «шапочкой слизи». Поверхность основании волоска плотная и имеет структуру, аналогичную структуре поверхности наружных клеточных оболочек зон растяжения и дифференциации. В статье обсуждаются возможности и перспективы использования сканирующей электронной микроскопии в биологических исследованиях.

ИЗУЧЕНИЕ ЭКОЛОГИИ МХОВ В ЛЕСОСТЕПНЫХ СООБЩЕСТВАХ НА ОБРАЗЦОВОЙ ТЕРРИТОРИИ ЧЕВХАРАСТИ IBP

Т. ШИМОН и Г. СЕРЕНЬИ

Образцы брались в ксеротермических сообществах: *Brometum tectorum, Festucetum vaginatae, Festucetum wagneri, Astragalo-Festucetum sulcatae, Junipero-Populetum, Festuco-Quercetum, Convallario-Quercetum.* Образцы почвы (почти 200 образцов) происходят из подушек мха. Исследовались величины pH, (в H_2O) содержание гумуса, $CaCO_3$, NH_3, NO_2^- NO_3^-, P_2O_5 и K_2O с помощью быстрых аналитических (так называемых полумикро-) методов. На изучаемой территории среднегодовое количество атмосферных осадков составляет 500—550 мм, а среднегодовая температура — 10—11 °C. Основная порода — известковый песок. Почвенные мхи играют значительную роль в производительном ярусе песчаной экосистемы, это отражается также в их количестве. В работе приводятся характерные черты отдельных видов мхов с точки зрения изучаемых показателей почвы, а также их общее ценологическое и экологическое поведение. После этого дается анализ связей бриоэкологических видовых групп с исследованными показателями почвы. Значение pH ксерофитных видов находится в нейтральном и щелочном, ксеро-мезофитных видов в нейтральном, а мезофитных видов в нейтральном и кислом интервалах.

Показатели гумуса ксерофитных видов более низкие, а мезофитных видов более высокие. NH_3 увеличивается соответственно градиенту от ксерофитных до мезофитных видов. Подобное положение наблюдается и в отношении NO_2^- и NO_3^-. Распределение фосфора и калия в связи с отдельными видовыми группами не показывает закономерности. В связи с отдельными показателями указывается также на их сезонные изменения.

ДАННЫЕ К ВОПРОСУ О НАСЛЕДОВАНИИ СОДЕРЖАНИЯ КАМАЗУЛЕНА В ПОПУЛЯЦИЯ РОМАШКИ

Й. ШВАБ и И. ШАРКАНЬ

В результате работы по селекции ромашки, проводившейся за последних 15 лет, в Венгрии были получены два новых сорта, содержание действующего вещества которых значительно больше, чем в местных популяциях. Эти два сорта дают возможность для улучшения дикорастущих местных популяций засоленных почв. Однако, до их использования выдвинулась необходимость предварительного уяснения нескольких основополагающих вопросов.

Пришлось выяснить возможность и размер скрещивания дикорастущих мелкоцветковых и селекционных сортов, годность и конкурентную способность новых сортов в смешанной популяции, а также ход наследования концентрации камазулена в растениях ромашки. Далее пришлось исследовать возможное влияние почвы на содержание действующего вещества в новых сортах при их культивировании на засоленной почве. В работе обсуждаются результаты экспериментов по выяснению вышеуказанных вопросов, проводившихся на основе исследования динамики популяций.

ИЗУЧЕНИЕ РАСПЕДЕЛЕНИЯ АТМОСФЕРНЫХ ОСАДКОВ В ЭКОСИСТЕМЕ ДУБОВОГО ЛЕСА В ТЕЧЕНИЕ ГОДА

М. САБО

Автором в 1974 году было проведено изучение распределения атмосферных осадков и пути до почвы в экосистеме *Quercetum petraeae cerris*, относящейся к «Шикфекут Проект», изучаемого в рамках венгерской программы МАВ. Было установлено, что в случае атмосферных осадков в 595,3 мм лиственный и кустарниковый ярусы исследованной экосистемы задерживают 20,1% общего количества дождя. В течение вегетационного периода это количесто составляет 21,2%, а во время листопада водозадержание уменьшается до 14,9%.

Количество воды, проникающей через лиственную крону, в течение периода исследования составило в среднем 78,8%. За вегетационный (лиственный) период леса это количество составило 75,9%, в то время как в период покоя (безлиственное состояние) леса — 81,2%. На количество воды, проникающей через лиственную крону, влияет также видовой состав насаждения.

Величина насыщенности лиственного яруса также зависит как от видового состава деревьев, так и от времени года. В вегетационный период эта величина равна 1,45 мм, а в безлиственный период — 0,85 мм.

Количество воды, стекающей по стволам (stemflow) за вегетационный период составило в среднем 2,9%, в безлиственный период — 3,9%, а в течение всего года исследования — 3,1%. Стекание воды по стволам начинается только в случае выпадения дождя выше 5 мм.

ДЕЙСТВИЕ ЗАТОПЛЯЮЩЕГО ОРОШЕНИЯ НА ИСПАРЕНИЕ ВОДЫ РАСТЕНИЯМИ КУКУРУЗЫ ПРИ ДВУХ СПОСОБАХ СНАБЖЕНИЯ ПИТАТЕЛЬНЫМИ ВЕЩЕСТВАМИ

Ш. СЛОВАК

Автор изучал действие затопляющего орошения на транспирацию растений кукурузы и установил, что вода вызывает гниль корней и увядание, вследствие чего наблюдается значительное уменьшение испарения воды. Уменьшение испарения воды вследствие затопляющего орошения было значительно больше после предварительного искусственного удобрения, чем без удобрения.

ПАРАМЕТРЫ РОСТА LAR, RGR и NAR ПО МЕЖДУУЗЛИЯМ РАСТЕНИЙ; УРОЖАЙ И ПРОДУКЦИЯ ЭФИРНЫХ МАСЕЛ PIMPINELLA ANISUM ПРИ СРОКАХ ПОСЕВА

Й. СУЙКО-ЛАЦА, З. СЕЧ и Л. ХОРНОК

На основе фенометрического исследования и анализа роста отдельных междуузлий при срока посева аниса можно установить, что в пределах отдельных растений, в отношении параметров роста, а также между различными параметрами наблюдаются значительные отклонения. Отклонения можно связать с возрастом и локализацией междуузлий — в качестве растительных факторов —, и отчасти и условиями внешней среды. Продуктивность и ее различия можно отнести отчасти к факторам морфологического характера и отчасти к физиологическим отклонениям активности. Под влиянием отдельных архитектурных элементов, напр. интенсивного роста боковых побегов, могут получаться величины RGR со знаком минус, вопреки нарастанию величин LAR.

На повышенный вредный эффект или эффекты факторов среды могут реагировать все присутствующие популяции вида, независимо от времени посева и от стадии развития.

Согласно результатам анализа роста, числа междуузлий и измерений урожая, содержания и состава эфирных масел, при позднем посеве наблюдается укорочение вегетационного периода аниса и, в пределах этого, также отдельных стадей онтогенеза. Параллельно с этим понижается прежде всего число архитектурных элементов, боковых зонтиков. Дальнейшие ступени означают укорочение междуузлий главного побега, а затем — уменьшение их числа. В соответствии с этим в значительной мере уменьшается также продуктивность и урожай растений.

Разница вегетационного периода насаждений с наименьшим и наипоздним сроком посева составляет 77 дней (27,1%), разница урожая — 87,4% и уменьшение накопления эфирных масел — 29,6%.

ИЗУЧЕНИЕ ЛОКАЛИЗАЦИИ ЭФИРНОГО МАСЛА С ПОМОЩЬЮ 2-^{14}C-АЦЕТАТА НАТРИЯ В ТКАНЯХ ЛИСТЬЕВ SALVIA SCLAREA L. И В ТКАНЯХ ЛИСТЬЕВ И ЦВЕТОНОСНЫХ СТЕБЕЛЬКОВ SALVIA OFFICINALIS L.

Г. ВЕРЗАР-ПЕТРИ и М. ТЕН

Авторы проводили с помощью 2-^{14}C-ацетата натрия и неактивных гистохимических методов сравнительное исследование биосинтеза и локализации эфирного масла, выявленного ими в прежней биохимической работе (1974 г.). Они устанавливают, что условия локализации железистых и покровных волосков различны и, следовательно, их функции также различны.

АНОМАЛИИ УСТЬИЦ В ЭПИДЕРМИСЕ ЛИСТЬЕВ КУКУРУЗЫ (ZEA MAYS)

Э. Ш. ВОЛЧАНСКИ и Г. ТУРЧАНЬИ

Различные аномалии устьиц наблюдались авторами как в эпидермисе листьев сорта кукурузы «Fehér mazsola» так, и в эпидермисе листьев контрольных и облученных растений инбредной линии «WF 9». У растений сорта «Fehér mazsola» только при дозах 3000 и 5000 рентген была обнаружена деформация устьиц, число и разнообразие форм которых было меньше, чем у внутрисортовой линии «WF 9». Деформация устьиц, в первую очередь, возникла в эпидермисе верхних листьев. Она не была связана с какими-нибудь другими внешними или внутренними деформациями. Большинство этих аномалий было описано у различных групп растений, но данные, касающиеся семейства Злаковых в литературе найти не удалось.

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NEW PLANTS IN CUBA IV

By

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(Received July 10, 1975)

The present study contains the descriptions of 21 taxa new to science, as follows: **Polygonaceae:** *Coccoloba* (1 sp.); **Euphorbiaceae:** *Leucocroton* (1 sp.); **Sapindaceae:** *Thouinia* (1 sp.); **Celastraceae:** *Crossopetalum* (1 ssp., 1 var.); **Rhamnaceae:** *Auerodendron* (1 var.), *Reynosia* (1 sp.); **Combretaceae:** *Terminalia* (1 sp.), *Bucida* (1 sp.); **Myrtaceae:** *Psidium* (1 sp.), *Calycorectes* (1 sp.), *Pimenta* (1 sp.), *Myrcia* (1 sp.), *Myrtus* (1 sp., 1 hybr.), *Eugenia* (1 sp.); **Melastomataceae:** *Calycogonium* (1 sp.); **Sapotaceae:** *Bumelia* (1 sp.); **Scrophulariaceae:** *Bacopa* (1 sp.); **Rubiaceae:** *Schmidtottia* (1 var.), *Rondeletia* (1 sp.).

Fam.: **Polygonaceae**

Coccoloba munizii Borhidi sp. nova

Arbor ad 8—9 m alta, parum ramificata (Alain). Rami ad nodos dilatati v. parum incrassati glabri. Ochreae 5—10 mm longae, glabrae, postremo lignescentes. Folia glabra crasse et rigide coriaceae, petiolis 8—12 mm longis, 4—7 mm crassis, supra late sulcatis suffulta, orbicularia vel levissime obovata, basi profunde cordata, reniformia vel auriculata, apice truncata vel rotundata, 7—15 cm longa et 5.5—12 cm lata, nervo medio utrinque crassiuscule prominente, lateralibus utroque latere 6—9 utrinque prominulis, supra dense, subtus laxe reticulato-venosis, supra nitidula, subtus opaca, punctis grandibus utrinque laxe disposita, margine subintegra, incrassata, plana. Inflorescentiae laterales solitariae vel terminales 1—3, 2—10 mm longe pedunculatae, multiflorae; rhachis 5—10 cm longa, 2—5 mm crassa, glabra, angulatostriata. Flores masculini ad 2, purpurei, pedicellis ad 0.5 mm longis, ochreolae 2 mm longae, purpureae, galbrae, margine membranaceae, extus punctatae. Perianthii masculini tubus 1 mm longus, lobi ovati vel obovati, 2—2.5 mm longi, purpurei, glabri, extus punctati. Stamina 2.5 mm longa, filamenta subulata, glabra, ad 2 mm longa, antherae suborbiculares ad 0.5 mm longae. Ovarii rudimentum compressum vel leviter trigonum, 0.6 mm longum, stylus rudimentarius 1, ad 1 mm longus. Fructus non visus.

Holotypus: Alain 7571; Prov. Oriente; in fruticetis serpentinosis ad Ermita, N. de Yunque de Baracoa in 150 m.s.m. Leg.: Acuña, Alain et Ramos 15. jan. 1960

Obs.: *C. baracoënsis* O. C. Schmidt affinis, quae ramis petiolisque pilosis, foliis minoribus, nervis lateralibus supra inconspicuis, subtus dense glanduloso-punctatis, inflorescentia tenui pilosa omnino differt. *C. uvifera* et *C. northropiae* pedunculis ochreolas superantibus, inflorescentiis pilosis clare discrepant.

Fam.: **Euphorbiaceae**
Leucocroton moncadae Borhidi sp. nova

Arbor ad 8 m alta. Cacumen oblongatum. Rami vetustiores virides, lenticellis linearibus obsiti, hornotini pilis multiradiatis perbrevibus flavido-tomentosi. Folia petiolis 1—2.5 cm longis, supra planis vel apicem versus tenuiter sulcatis, ad 3 mm latis, flavido-tomentosis, basi insertis suffulta, elliptica, obovata vel oblongo-elliptica, basi rotundata vel subcordata, apice rotundata vel breviter acuminata, obtusa vel leviter emarginata, 5—14 cm longa, 2—6.5 cm lata basi 3-nervia; nervis supra impressis, subtus prominentibus et venis subhorizontalibus anastomosantibus, lateralibus utroque latere 3—5 basalibus apicem versus arcuatis ante marginem conjunctis; supra glabra, nitida, viridia, subtus inter nervos pilis radiatis minutissimis albis adpresse tomentosa, ad nervos pilis stellatis flavidis sparsis obtecta, albicantia; margine integra, plana vel tenuiter recurva, subcoriacea. Inflorescentiae masculae laterales vel axillares, solitariae, 1.5—6.5 cm longae, 0.5—2 cm longe pedunculatae, multiflorae, pube ramorum. Flores in racemo laxe dispositi sessiles, 3-bracteatae; bractea inferior oblongo-triangularis 2 mm longa, laterales 1 mm longae, pedicelli nulli. Alabastra globosa, apiculata, 3 mm longa, sepala 4, triangulari-ovata, acuta, fulvo- vel ferrugineo-tomentosa, intus albo-villosa. Stamina 18—28, filamenta basi connata, 1 mm longa, glabra, in disco villoso inserta, antherae oblongo-ovatae, 2 mm longae, luteae. Inflorescentiae femineae in axillis solitariae, 2—3 cm longae, 1-florae. Pedunculus flavo stellato-tomentosus, bracteis sterilibus late triangularibus, 1—2 mm longis crassisque laxe dispositis, suffultus. Flos terminalis sessilis, sepala 5, oblongo-ovata, 3—3.5 mm longa, apice rotundata, extus pilis stellatis rufis, intus pilis albidis dense tomentosa. Capsula tricocca, globosa, 8—10 mm longa, adpresse flavido-tomentosa. Semina nigra, 5—6 mm in diametro.

Holotypus: 27688/A SV; Prov. Habana; in silvis fruticosis serpentinosis montis Loma de Coca pr. pag. Campo Florido. Leg.: A. Borhidi et M. Moncada; 12. nov. 1974. Ibidem 27688/B, 27688/C; isotypi in SV et Bp. — Prov. Las Villas: Presa Grande cerca de la Presa de Agabama, E. Del Risco 27315 SV; — Prov. Camagüey: La Ciega, Caobilla, Acuña 4414, 14534!

Obs.: Habitu *L. virentis* Griseb. affinis, qui foliis chartaceis, subtus stellato-pilosis, pallide viridibus, inflorescentia mascula brevi glomerata, albotomentosula, staminibus 8—12 optime differt.

Fam.: **Sapindaceae**
Thouinia acunae Borhidi et Muñiz sp. nova

Frutex vel arbor parva, 2—3 m alta. Rami hornotini teretes, dense flavo-pubescentes. Internodia 3—10 mm longa. Folia 1-foliolata resp. simplicia ad apicem ramorum manifeste conferta, petiolis 2—5 mm longis flavo-pubescentibus suffulta, orbicularia vel late obovata, 2,5—4,5 cm longa, 2—3,5 cm lata, basi obtusa, rotundata v. subcordata, apice truncata et spinuloso-mucronata, margine regulariter spinuloso-dentata, dentibus utroque latere 8—11, nervo medio supra in sulco prominulo, subtus arcte prominente, lateralibus utroque latere 8—11 utrinque prominentibus et reticulato venosa, supra ad nervos sparse pilosa, subtus ad nervos pilis patentibus flavo-puberula, in axillis nervorum non barbata, inter nervos glandulis minutis brunneis prominentibus punctata, manifeste bullata, coriacea. Cetera non visa.

Holotypus: Alain 7391; Prov. Oriente; in saxosis calcareis ad Florida Blanca pr. pag. Alto Songo 450 m.s.m. Leg.: Acuña, Alain et M. López Figueiras, 10. jan. 1960. LS; isotypus: SV.

Fam.: **Celastraceae**

Crossopetalum ternifolium (Urb.) Alain
ssp. **moaënse** Borhidi et Muñiz ssp. nova

A typo differt: foliis majoribus, 2—3.5 cm longis, 1.5—3 cm latis, nervis lateralibus utroque latere 12—16, dentibus lateralibus 4—8, pedunculis 1.5—4 cm longis, patenti-puberulis.

Holotypus: Alain 1030; Prov. Oriente; Moa: Pinar de la Esmeralda, Sur de Cananova. Leg.: Alain, Clemente et Crisógone, 21. jul. 1949. LS; isotypi: LS et SV.

Crossopetalum rostratum (Urb.) Roth
var. **grandifolium** Borhidi et Muñiz var. nova

A typo differt: foliis 4—8 mm longis, lobis lateralibus utroque latere 8—12, subtus breviter adpresse pilosus.

Holotypus: León 13210; Prov. Pinar del Rio; Sierra del Rosario: Loma Pelada de Buenavista de Cayajabos. Leg.: León, 20. dec. 1927; LS. Isotypi: LS, SV.

Fam.: **Rhamnaceae**

Auerodendron cubense (Britt. et Wils.) Urb.
var. **maisiana** Borhidi et Muñiz var. nova

A typo differt: foliis late obovatis vel suborbicularibus, apice profunde excisis, pedunculis brevioribus.

Typus: Alain 7037; Prov. Oriente, Mesa de Lindero, Maisi; Leg.: 30. dec. 1957. Alain et López Figueiras. LS. — Specim. exam.: Llano de Maisi, Alain 7078; Mesa de Chivo, Maisi, León, Marie-Victorin et Carabia 17158; Monte Cristo, Jauco, Acuña et Barreto 17455.

Reynosia moaënsis Borhidi et Muñiz sp. nova

Arbor parva. Rami hornotini angulati, glabri, internodiis 1—2 cm longiis. Stipulae triangulares integrae, 0.5—0.7 mm longae, margine ferrugineo-pilosae, caducae. Folia opposita, 4—8 mm longe petiolata, elliptica vel ovata, apice rotundata et emarginata, basi obtusa, rotundata vel truncata, 3.5—6 cm longa, 2—4 cm lata, nervo medio supra impresso, subtus prominente, lateralibus supra prominentibus et utrinque reticulatis, margine integra, plana, vel tenuiter recurva, chartacea vel subcoriacea. Pedicelli axillares solitarii vel fasciculati, fructiferi 7—12 mm longi, 0.3—0.5 mm crassi, erecti, glabri. Alabastra semiglobosa, antice paullo convexa et breviter apiculata. Calycis tubus semiglobosus, glaber, 2—3 mm in diam., lobi triangulares, acuti et acuminati, apice subulati, 1,5—2 mm longi, intus carinati. Petala 5, late obcordata, brevissime stipitata, antice profunde excisa, vix supra 1 mm longa. Stamina petala vix superantia, filamenta subulata, 0.7 mm longa, antherae ovatae. Stylus 0.5 mm longus, in 1/3 superiore brevissime bilobus. Ovarium ovatum, pseudobiloculare, placentis binis juxtapositis non connatis. Ovula in quoque loculo solitaria. Fructus drupaceus, subglocosus, 1—1.4 cm in diam. Semen solitarium forma drupae. Endospermium copiosum, ruminatum.

Holotypus: CLEMENTE 4484; Prov. Oriente; Moa, Mina Narciso, Cayoguán. Leg.: CLEMENTE et CRISÓGONE, 2. jul. 1945. LS.

Specim. exam.: Moa: Rio Cayoguán, CLEMENTE 4487; CLEMENTE, MARIE-VICTORIN et ALAIN 21631, 21828; — Camino Mina Delta, Puente del Rio Cayoguán, CLEMENTE 4602; — Moa: Aeropuerto, ACUÑA 12547; Cañete, ROIG 6599.

Obs.: *R. wrightii* (Griseb.) Urb. affinis, quae foliis majoribus, margine undulatis, membranaceis vel subchartaceis, pedicellis fructiferis 4—5 mm longis et 0.5—0.7 mm crassis, patentibus, fructibus 18—22 mm in diam. clare differt.

Fam.: **Combretaceae**

Terminalia pachystyla Borhidi sp. nova

Arbor parva, ad 8—10 m alta. Rami hornotini teretes, striati glabri. Folia alterna vel subopposita, 0.5—2 cm longe petiolata, petiolis striatis, supra tenuiter canaliculatis, glabris, obovata vel oblongo-obovata, 4—12 cm longa, 2.5—4 cm lata, apice rotundata vel truncata, plerumque leviter emarginata, basi longe angustata, glandulis 2, marginalibus praedita, nervo medio supra prominulo, subtus prominente, lateralibus utroque latere 6—9 utrinque prominulis, ad marginem anastomosantibus. Limbus supra viridis, nitidus, subtus pallidior, utrinque glaber, chartaceus vel subcoriaceus, margine integer, recurvus. Inflorescentiae terminales racemosae, dense multiflorae, 5—8 cm longae, glabrae. Hypanthium 3—4 mm longum, glabrum, calycis tubus 5—6 mm latum, 4 mm longum, lobi 2.5—3 mm longi, extus glabri, intus ferrugineo-puberuli, basi dilatati, 3 mm lati, antice abrupte angustati et apiculati, apice obtusi. Discus ferrugineo-villosus. Stamina 10 in seriebus 2, filamenta inaequalia, glabra, 6—8 mm longa, e tubo calycis longe exserta. Stylus erectus, crassus, valde exsertus 10—12 mm longus, stamina longe superans, 1—2 mm in diam., cylindricus, apicem versus leviter angustatus, quasi per totam longitudinem ferrugineo-pubescens, apice truncata 1 mm longe glaber.

Holotypus: ALAIN 5368; Prov. Oriente; Sierra del Cristal; Loma de los Mulos supra opp. Nicaro. Leg.: ACUÑA, ALAIN et LÓPEZ FIGUEIRAS, 2—7. apr. 1956. SV; isotypus: LS.

Specim. exam.: Sierra del Cristal, Rio La Ceiba, Nicaro. Leg.: G. BUDOWSKI 19585 SV.

Obs.: Habitu *T. orientensis* Monachino valde affinis, quae floribus minoribus, lobis calycis triangularibus, staminis stylum superantibus, stylo 5 mm longo, medio latissimo, inferne ferrugineo-villoso statim discernenda.

Bucida palustris Borhidi et Muñiz sp. nova

Arbor usque 12—15 m alta, cacumen umbraculiforme, rami ascendentes vel horizontaliter elati, apice spinis 2—3 terminalibus 5—15 mm longis. Folia conferta, 2—4 mm longe petiolata, petiolis adpresse puberulis, oblongo-obovata, 1.5—3.5 cm longa, 5—15 mm lata, apice rotundata vel truncata, plerumque emarginata, basi cuneata et in petiolum contracta, 2 glandulas obsoletas gerentia, utrinque glabra, chartacea. Inflorescentiae terminales vel axillares 1—5, subcapitato-racemosae, 2—4 cm longae, albo-strigillosae vel glabrescentes, 7—13-florae. Pedunculus foliis aequilongus, sericeo-albo-puberulus, postremo glabrescens vel glaber. Flores ad apicem rhachidis confertae. Bracteolae ovatae, 1 mm longae, glabrae. Hypanthium cum rhachide dense et adpresse albo-strigillosum, in anthesi 2—2,5 mm longum. Tubus calycis late campanulatus, 2—2.5 mm longus et 3 mm latus, extus pilis albo-sericei sparse et adpresse pilosus vel glabrescens, intus longe albo-villosus. Lobi calycis late triangulares. Stamina 10 in seriebus 2, 4—5 mm longa, e calyce longe exserta. Stylus 4 mm longus, exsertus, quasi per totam longitudinem villosus, apice rectus. Fructus 4—5 mm longus, albo-sericeus.

Holotypus: Prov. Matanzas; Peninsula Zapata in silvis paludosis pr. pag. Guamutal. Leg.: A. Borhidi, E. Del Risco et R. Oviedo, apr. 1975. SV; isotypi: SV, Bp.

Obs.: *B. subinermis* Bisse affinis, quae foliis subsessilibus, inflorescentiis glabris, tubo calycis utrinque glabro bene differt.

Fam.: **Myrtaceae**

Psidium munizianum Borhidi sp. nova

Frutex 1—2 m altus. Rami hornotini leviter compressi, glaberrimi, nitidi, glandulis dissitis granulati. Folia 2—4 mm longe petiolata, petiolis 1.5—2 mm crassis, nitidis, glabris, glanduloso-rugosis; ovata vel late elliptica, basi truncata vel leviter rotundata, apice rotundata et emarginata, 3—5.5 cm longa, 2—3.5 cm lata, nervo medio applanato vel leviter prominulo, flavido, lateralibus utroque latere 7—10 sub angulo 75—80° abeuntibus, supra ± prominulis et anastomosantibus, subtus prominentibus et reticulatis, margine irregulariter crenulata et leviter recurva, utrinque glandulis nitidis prominentibus pellucidis punctata, supra glabra nitida, subtus opaca, glaberrima, flavicantia, coriacea. Pedunculi axillares 2—3 cm longi, 1-flori, glabri. Calycis tubus obovatus, glaber, glandulis impressis punctatus, 4—5 mm longus et 3 mm latus, basin prophyllis 2 caducis. Lobi 4, liberi, oblongo-ovati, 3—4 mm longi, basi 2.5—3 mm lati, apice rotundati, utrinque glandulosi et glabri. Petala staminaque non visa. Ovarium superne valde concavum. Bacca non pleno matura ovata, 6—7 mm longa, 4—5 mm crassa, nigra, glabra, 2-locularis. Semina 4—5, ± ovata.

Holotypus: Alain 6805; Prov. Habana; in fruticetis litoralibus La Rotila pr. pag. Santa Cruz del Norte, 10. oct. 1959. LS.

Obs.: *P. crenulati* Urb. et Ekm. affinis, quod ramis hornotinis teretibus, patenti-pilosis, foliis 1—2 mm longe petiolatis, subtus pilosulis, pedicellis 4—15 mm longis clare differt.

Calycorectes moana Borhidi et Muñiz sp. nova

Frutex vel arbor parva. Rami hornotini anguste 4-alati, glabri. Folia petiolis pilosulis 1—3 mm longe petiolata, opposita, elliptica vel ovata, 1.2—3.5 cm longa, 0.7—2 cm lata, basi obtusa vel rotundata, rariter cuneata, apice obtusa vel breviter acuminata, nervo medio supra impresso, subtus inferne prominente, apicem versus appianato, leviter impresso vel evanescente, lateralibus utrinque nullis, vel subtus 8—12 vix conspicuis. Limbus ± rugulosus, supra dense et minutissime, vix conspicue impresso-punctatus, subtus punctis pellucidis sparsis vix conspicuis obsitus; supra in sicco olivaceus, subtus brunneus, utrinque nitidus, crasse coriaceus, margine revolutus. Flores in axillis foliorum 1—2. Pedicelli 4—12 mm longi, glanduloso-granulati. Prophylla 2, linearia, 1—1,5 mm longa, caduca. Calycis tubus cylindricus, non turbinatus, sub lobis non constrictus. Alabastrum semiglobosum, plane clausum, in apiculum brevissimum contractum, sub anthesi in lobos 4 (rarissime 5) subaequales, ovatos, apiculatos, margine incrassatos, 3.5—4 mm longos valvatim disruptum. Petala 4, sepalis ± aequilonga, orbicularia, 4—5 mm longa et lata, margine glabra. Stamina toro brevissime piloso 4-seriatim inserta; filamenta filiformia, apice subulata, 3 mm longa, antherae obovatae. Stylus 5 mm longus, superne vix attenuatus; stigma parvum, convexum, stylo aequicrassum. Ovarium vertice planum, glabrum, 2-loculare. Ovula in quoque loculo 6—8, reniformia, columna centrali affixa. Semina 2.

Holotypus: Acuña 13257; Prov. Oriente; Moa: Mina Franklyn; 10. nov. 1945. SV.

Specim. exam.: Moa: Cerro Miraflores, A. Borhidi, R. Capote et R. Oviedo, 12. sept. 1974. — Camino de Mina Johnston, Acuña 13251; León

et CLEMENTE 23216. — Mina Franklyn, LEÓN et CLEMENTE 23353; LEÓN, CLEMENTE et NESTOR 5537; — Mina Delta, LEÓN, CLEMENTE, NESTOR et CRISÓGONE 4522; — Monte La Breña, CLEMENTE 4964; — Piedra la Vela, Sierra de Moa, ALAIN 3384.

Obs.: *C. ekmanii* Urb. affinis, quae ramis hornotinis pilosis, foliis subtus eglandulosis, floribus 1—2 mm longe pedicellatis, plerumque 5-meris, calycis tubo breviter turbinato omnino differt.

Pimenta (Myrtekmania) moaënsis Borhidi et Muñiz sp. nova

Arbor parva ad 2—4 m alta. Rami hornotini ad gemmas apicales tantum ferrugineo-pilosi, ceterum glabri, teretes, glanduloso-granulati, rufi, vetustiores cinerascentes. Folia 4—7 mm longe petiolata, elliptica vel leviter obovata, basi cuneata et in petiolum contracta, antice rotundata vel obtusa, minute emarginata, 2.5—4 (—5) cm longa, 1—2 cm lata, nervis utrinque reticulato-conjunctis, utrinque inaequaliter rufo vel brunneo-punctata, glabra, coriacea, margine integra et tenuiter recurva. Inflorescentiae axillares cymosae, 3—9-florae. Pedunculus filiformis, 1—2.2 cm longus, 0.2—0.3 mm crassus. Prophylla nulla, pedicelli terminales 3—5 mm longi, lateralibus ± aequilongi, basi ferrugineo-puberuli. Calyx dense glanduloso-granulatus; tubus obconicus, glaber, supra ovarium non productus; lobi 4, liberi, in aestivatione valvati, suborbiculares, 0.7—0.8 mm longi, concavi, margine ciliati, extus glabri et glandulosi, intus ferrugineo-puberuli. Petala 4, orbicularia, vix stipitata, 1.5 mm in diam. glandulosa. Receptaculum manifeste ampliatum, densissime ferrugineo-pubescens. Stamina pluriseriata; filamenta 1.5—2 mm longa, antherae subquadratae. Ovarium apice usque ad receptaculum productum, vertice planum, 1-loculare. Ovula 2, sub apice cavitatis pendula

Holotypus: LEÓN 23257; Prov. Oriente; Playa de Moa, 22. jul. 1947. Leg.: LEÓN et CLEMENTE; LS.

Specim. exam.: Playa de Moa, CLEMENTE 5564; — Pinares de Puerto de Moa, LEÓN 22516.

Obs.: *Myrtekmaniae filipedis* Urb. affinis, quae foliis 1—2 mm longe petiolatis, 1—1.8 cm longis, inflorescentia 3-flora, floribus terminalibus sessilibusque optime differt.

Myrcia (Mozartia) pineticola Borhidi et Muñiz sp. nova

Arbor parva ad 3—4 m alta. Rami hornotini leviter compressi, glandulosi. Folia petiolis 5—7 mm longis, supra profunde sulcatis suffulta, elliptica vel oblongo-ovata, basi acuta, apice obtusa vel rotundata et emarginata, 3.5—6.5 cm longa, 1.2—3 cm lata, nervo medio supra impresso vel apicem versus prominulo, lateralibus utroque latere in reticulo prominente vix distinctis 10—15, utrinque prominentibus, supra pallide viridia et dense nigro-punctata, subtus glandulis brunneis pellucidis et transparentibus abunde obtecta, pallidiora, rigide coriacea. Inflorescentiae axillares et ex internodiis sine folio materno prodeuntes, pedunculis 2—3 cm longis, tenuibus, superne 0.3 mm latis, cymosae 1—3-florae; bracteae nullae. Pedicelli terminales nulli vel subnulli, laterales 4—7 mm longi; prophylla nulla. Baccae sphaeroideae vel ovatae, 6—9 mm longae et 4—6 mm latae, glanduloso-granulatae, glabrae, lobis calycinis 4, ovatis, 1.5 mm longis margine pilosis, persistentibus coronatae, 1-loculares, 1-spermae. Semina rotundata, convexa, brunnea, in apice baccae affixa, rugulosa, 4—5 mm in diam. Testa membranacea, embryo glanduloso-punctatus.

Holotypus: 27691 SV; Prov. Oriente; Moa: in pinetis montis Cerro Miraflores. 12. sept. 1974. Leg.: A. BORHIDI, R. CAPOTE, R. OVIEDO.

Obs.: *Myrciae emarginatae* (Mold.) Alain affinis, quae foliis eglandulosis, pedunculis 1.5—2 cm longis, pedicellis lateralibus subnullis, floribus fructibusque basi prophylla gerentibus, baccis usque 6 mm longis clare differt.

Myrtus acunae Borhidi et Muñiz sp. nova

Frutex vel arbor parva, 2—3 m alta. Rami hornotini leviter compressi, minute cinereo-puberuli, rariter glabrescentes. Folia 3—5 mm longe petiolata, petiolis puberulis, ovata vel oblongo-cordiformia, basi cordata, vel rotundata, apice obtusa vel rotundata, rariter acutiuscula, 1.5—4 cm longa, 1—2.5 cm lata, nervo medio supra prominente et inferne piloso, subtus crassiuscule prominente, lateralibus utroque latere 6—9 manifeste prominentibus et reticulato-anastomosantibus, reticulo supra bene conspicuo et tenuiter prominulo, subtus crassiuscule prominente, glandulis densis utrinque prominulis, saepe translucidis obsita, margine incrassata, integra et tenuiter revoluta, supra nitentia, utrinque viridia vel supra flavicantia, subtus brunnescentia, rigide et crasse coriacea. Flores ex axillis euphyllorum vel basi ramulorum in axillis bractearum obovatarum solitarii vel fasciculati. Pedunculi 1-flori, 1—2 cm longi, striati, glabri vel basi pilosuli. Prophylla sub calyce 1—1.5 mm longa, acuta, pilosa, decidua. Calycis tubus obovatus, glaber, lobi 4, in alabastro tenuiter imbricati, liberi, inaequimagni, late ovati, antice rotundati vel breviter acuti 2—3 mm longi, glanduloso-punctati, glabri. Petala 4, orbicularia, 3.5—4 mm longa, eglandulosa, glabra. Receptaculum pilosum. Filamenta pluriseriata, filiformia, glabra, 4 mm longa; antherae 0.5 mm longae, subquadratae. Stylus 4 mm longus, 0.5 mm crassus, glandulosus. Stigma convexum, brevissime bilobatum. Ovarium 2-loculare; ovula in quoque loculo 10—14 cc. 4-seriata. Semina 8—12.

Typus: ACUÑA 19735 SV; Prov. Oriente; Sierra del Cristal; Loma Escalera, Nicaro. Leg.: ACUÑA et ZAYAS, 26—27. maj. 1955. Isotypus: ACUÑA 19736 SV.

Specim. exam.: Sierra de Nipe: Loma Bandera; A. BORHIDI, R. CAPOTE, R. OVIEDO, SV; LÓPEZ FIGUEIRAS UO 2052; — Loma del Winch; ALAIN, ACUÑA et RAMOS 8047; LÓPEZ FIGUEIRAS UO 2568; — Cumbre de la Loma Mensura, LÓPEZ FIGUEIRAS UO 2528; — Salto del Rio Guayabo, LÓPEZ FIGUEIRAS UO 970. — Sierra del Cristal: Saca Lengua, ALAIN, ACUÑA et LÓPEZ F. 5425; — Subida de Serrucho, ALAIN, ACUÑA et LÓPEZ FIGUEIRAS 5398.

Obs.: *M. ekmanii* Urb. affinis, quae ramulis, petiolis, bracteisque glabris, foliis majoribus, basi cuneatis vel obtusis, nervis lateralibus utrinque obsoletis, floribus semper solitariis et longiore pedicellatis bene differt.

Myrtus × miraflorensis Borhidi et Muñiz hybr. nova
(M. ophiticola (Britt. et Wils.) Alain × **M. ekmanii** Urb.)

Frutex vel arbor parva, 2—4 m alta. Rami hornotini compressi, pilis simplicibus sparse puberulis, 5—8 mm longis, ovata vel elliptica, 3—6 cm longa, 2—3.5 cm lata, basi obtusa, antice rotundata et breviter emarginata; nervo medio supra leviter impresso, lateralibus supra obsoletis, subtus utroque latere 7—9 sub tomento tenuissimo clare conspicuis et reticulatis, folia supra ad nervum medium inferne pilosa, caeterum glabra, nitida et flavicantia, glandulis nigrescentibus leviter prominulis obsita, subtus pilis brevissimis cinereo-pubescentia, grisaceo-opaca, glandulis nigris prominulis punctata, margine anguste revoluta, coriacea. Flores in axillis foliorum, ex axilla bracteae obovatae, 2 mm longae tomentosulae solitarii; pedunculus 1.5—3.5 mm longus, glanduloso-punctatus et sparse pilosus. Prophylla 2—3 mm longa, glandulosa et pilosa, patentia, caduca. Calycis tubus obovatus, 5—6 mm longus, puberulus;

lobi 4 inaequimagni, in alabastro imbricati, liberi, 3—4 mm longi, margine fimbriati, dorso puberuli. Stylus 8 mm longus, glanduloso-punctatus, inferne pilosus, stigma discoideum. Ovarium biloculare, ovula cc. 20, semina 4, subreniformia.

Holotypus: 27676 SV; Prov. Oriente; Moa; Cerro Miraflores. Leg.: A. BORHIDI, R. CAPOTE, R. OVIEDO, 11. sept. 1974. Isotypi: SV., Bp.

Obs.: Verisimiliter planta hybrida introgressiva inter areas parentium. *M. ekmanii* Urb. ramis, foliis floribusque glabris, *M. ophiticola* foliis subtus dense tomentosis, glandulis reticulationeque inconspicuis, pedicellis calycibusque dense tomentosis differt.

Eugenia ramonae Borhidi et Muñiz sp. nova
(**E. crenulata** Willd. var. **cubensis** sensu León et Alain, non Berg)

Frutex 2—3 m altus. Rami hornotini teretes, brevissime hirtuli et glandulis prominentibus granulati. Folia petiolis puberulis et glanduloso-rugosis, 0.5—1.5 mm longe petiolata, bas obtusiuscula, apice acuta vel obtusa, plerumque mucronulata et recurva, oblongo-lanceolata, 6—12 mm longa et 3—5 mm lata; nervo medio supra inferne leviter impresso, antice evanescente, subtus prominente, sub apice leviter impresso, lateralibus utrinque nullis; supra impresso-punctata, pallide viridia, glandulis nigris prominulis laxe disposita, pallide glaucescentia, parce adpresse pilosa, margine incrassata, crenulata, apicem versus leviter tridentata, late recurva, ideoque naviculiformia, crasse et rigide coriacea. Flores axillares solitarii; pedicelli 6—10 mm longi, patenti-puberuli et glandulosi; prophylla 0.5—1 mm longa, triangularia, apiculata vel subulata, pilosa et translucide punctata. Lobi calycis 4, triangulares, acuti et acuminati, 1—2 mm longi, margine pilosi, translucide glanduloso-punctati. Stylus filiformis superne attenuatus, 4 mm longus. Bacca nigra, 5—6 mm in diam., glandulosa, superne adpresse pilosa, inferne glabra. Ovarium biloculare, ovulis in quoque loculo 5—7. Semen 1, sub apice affixum, ovato-subglobosum, 3—4 mm in diametro.

Holotypus: 27674 SV; Prov. Oriente; Moa: Playa de Vaca. Leg.: A. BORHIDI, R. CAPOTE et RAMÓNA OVIEDO, 13. sept. 1974. Isotypus: Bp.

Obs.: Ex affinitate *E. woodfredianae* Urb. quae ramis glabris, foliis subtus eglandulosis, margine integris abunde differt.

Fam.: **Melastomataceae**
Calycogonium acunanum Borhidi et Muñiz sp. nova

Arbor parva ad 3—5 m alta. Rami hornotini pilis stellatis dense ferrugineo-tomentosi. Folia petiolis angulatis, 6—8 mm longis, pube ramorum; lineari-lanceolata 3-nervia, 3.5—5 cm longa, 8—12 mm lata, basi angustata vel obtusa, antice longe angustata, obtusiuscula, apice ipso mucronato-acuta, plerumque recurva; supra in statu iuvenili stellato-tomentosa, mox glabra, viridia, nitida, foveolata, subtus pilis stellatis flavo-ferrugineis postremo cinereis arcte adpressis dense tomentosa; nervo medio supra profunde impresso, subtus crasse prominente, apice in mucronem prolongato, marginalibus 2 supra basim 1 mm abeuntibus, supra paullo mpressis, subtus prominulis, lepidibus rufescentibus obtectis, apicem versus utrinque evainescentibus, secundariis utroque latere 15—18 rectanulari abeuntibus utrinque obsoletis. Flores terminales 1—3. pedicellati et bracteati. Bracteae lineari-subulatae, ferrugineo tomentosae, 7—14 mm longae, caducae. Pedicelli 4-angulati, 3—5 mm longi, 1,5—2 mm crassi. Hypanthium fructiferum 8—10 mm longum, 6—7 mm in diam., ferrugineo-stellato-tomentosum, 4-angulatum, postremo cylindricum, supra ovarium contractum. Lobi calycis 4, late triangulares, in appendices angulosas, lineari-subulatas, 4—7 mm longas excurrentes. Fructus 3-locularis, apice 8-angulatus, ferrugineo-puberulus.

Holotypus: 27666 SV; Prov. Oriente; Pinares de Moa supra Playa de Vaca. Leg.: A. Borhidi, R. Capote, R. Oviedo, 10. sept. 1974.

Obs.: *C. revoluto* Alain affinis, quod foliis minoribus, 3—5 mm longe petiolatis, apice obtusis et emarginatis, floribus ebracteatis, sessilibus, appendicibus calycis 3—5 mm longis teretibus, fructibusque minoribus differt.

Fam.: **Sapotaceae**
Bumelia acunae Borhidi sp. nova

Frutex 2—3 m altus. Rami hornotini rufo-puberuli. Folia 0.5—1.5 mm longe petiolata, obovata vel late elliptica, 6—15 mm longa, 4—8 mm lata, utrinque enervia vel nervo medio subtus inferne prominulo, concaviuscula, supra nitida, glabra, subtus pilis rigidis ferrugineis vel rufis densissime strigosa postremo glabrescentia, margine integra, recurva, rigide coriacea. Flores laterales vel axillares 1—2, pedunculus 1—2 mm longus. Sepala oblongo-ovata vel lanceolata, apice acuta vel angustata et obtusa, 3—3.5 mm longa, extus rufo-hirsuta. Corolla 3.5—4 mm longa, tubus 2.5—3 mm longus, lobi 1—1.5 mm longi, cordati, apice acuti vel mucronati, sine lobulo laterali. Filamenta nulla, antherae tubo corollae superne adnatae, insertae, ovatae, 1 mm longae, apice acutae. Ovarium 1 mm longum, suborbiculare, glabrum; stylus 1 mm longus, conicus. Drupa globosa, 3.5—4.5 mm in diam.

Holotypus: Acuña 13303 SV; Prov. Oriente; Moa: Mina Franklyn. Leg.: Acuña, 10. nov. 1945.

Specim. exam.: Moa, Leg.: José Ferras, 15007 SV; — Moa: Mina Potosi, Leg.: V. Samek 26821 SV. — Ekman 4034 (ster.) ex pinetis litoralibus ad Rio Maravi probabiliter huc pertinet.

Obs.: *B. revolutae* Urb. affinis, quae foliis oblongis vel lineari-lanceolatis, 10—25 mm longis et 2—6 mm latis, 1.5—4 mm longe petiolatis, floribus minoribus, ovario puberulo et drupa minore clare differt.

Fam.: **Scrophulariaceae**
Bacopa minuta Borhidi et Muñiz sp. nova

Planta glabra, pusilla, caulibus diffusis, prostrato-pulvinatis, nodis radicantibus. Folia ovata vel suborbicularia, 1—3 mm longa et 1—2 mm lata, apice rotundata, basi obtusa vel leviter cuneata et in petiolum anguste alatum, 1 mm longum, glabrum, basi dilatato-amplexicaulem contracta; nervo medio supra nullo, subtus conspicuo, lateralibus nullis, folia supra reticulato-rugulosa, viridia, subtus pallidiora, utrinque glandulis profunde impressis obtecta, glabra, margine integra vel leviter crenulata. Flores axillares solitarii, sessiles vel subsessiles. Bracteolae 2, obovatae, ad 1 mm longae, calyce paullo breviores. Lobi exteriores calycis interioribus latiores, ovati, 1—1.5 mm longi, interiores oblongi, 2 mm longi, enerves, glabri. Corolla calycem paullo superans, 2—2.5 mm longa, alba, utrinque glabra, lobi 5, vix profundi, ± aequimagni, omnes obovato-subrotundati. Stamina 4, filamenta glabra, antherae subglobosae, insertae vel vix exsertae. Pedicellum fructiferum ad 0.5 mm longum, glabrum. Capsula dehiscens, ovata vel globosa, 1.5 mm in diam., 4-sulcata, stylo elongato, 2 mm longo coronata, glabra, eglandulosa. Semina brunnea, nitida, reticulato-rugosa.

Holotypus: Prov. Oriente: Moa in ripariis humidis serpentinosis ad Playa de Vaca. Leg.: A. Borhidi, R. Capote, R. Oviedo, 13. sept. 1974. SV; isotypus: Bp.

Obs.: *B. micromonnieriae* (Griseb.) Borhidi affinis, quae floribus coeruleis, 3—5 mm longe pedicellatis, folia superantibus, corolla 4—7 mm longa, lobis calycis exterioribus majoribus omnino differt.

Fam.: **Rubiaceae**

Schmidtottia cubensis (Britt. et Wils.) Urb.
var. **cristalensis** Borhidi et Muñiz var. nova

A typo differt: foliis supra glabrescentibus vel glaberrimis, corolla majore, 3.5—4.5 cm longa.

Holotypus: ALAIN 5402; Sierra del Cristal, Loma El Serrucho. Leg.: ACUÑA, ALAIN et LÓPEZ FIGUEIRAS 2—7. apr. 1956. SV; isotypus: LS.

Specim. exam.: Sierra del Cristal: Sierra Escalera, Nicaro, ACUÑA et ZAYAS 19805 SV; — Rio Lebisa, LÓPEZ FIGUEIRAS 194; — Loma El Serrucho, ALAIN, ACUÑA et LÓPEZ FIGUEIRAS 5403 LS; — Cresta de la Sierra del Cristal, ALAIN et LÓPEZ FIGUEIRAS 4821 LS; — Fuente del Rio Lebisa, EKMAN 15977.

Rondeletia susannae Borhidi sp. nova

Frutex 1—2 m altus. Rami hornotini pilis brevibus adpressis sericei, apice conferte foliosi, vetustiores cicatricibus inter sese 4—5—(10) mm distantibus gibberosi. Stipulae interpetiolares triangulari-subulatae, 3—5 mm longae, acutae et longe mucronatae, patentes. Folia 4—7 mm longe petiolata, ovata vel elliptica, basi cuneata vel obtusiuscula, apice acuta vel brevissime acutiuscula, rariter obtusa, 1.5—5 cm longa, 8—25 mm lata, nervis supra impressis, subtus prominentibus et reticulatis, supra glabra, nitida, viridia, in sicco plicatula et rugulosa, leviter bullata, nigricantia, subtus pilis tenuissimis et minutis densissime pilverulento-tomentosa, alba, margine plana, coriacea. Flores axillares solitarii, 5-meri, pedicelli 4—7 mm longi. Bracteae 2, lineares, 4—5 mm longae, basi connatae. Lobi calycis 5, triangulari-subulati, 4—5 mm longi, apice obtusi, albo sericeo-tomentosi. Capsula globosa, 4—5 in diam., albo-tomentosa.

Holotypus: Prov. Pinar del Rio; Sierra de la Güira: Mogote de la Güira. Leg.: A. BORHIDI et E. DEL-RISCO, 22. nov. 1974. 27695 SV; isotypi: 27696 SV, Bp.

Obs.: *R. bicolor* Britt. floribus 4-meris, *R. chamaebuxifolia* Griseb. stipulis brevioribus, foliis angustibus, subtus glabrescentibus, lobi calycis brevibus, triangularibus optime differunt.

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ANATOMICAL INVESTIGATIONS ON THE GENERATIVE ORGANS OF LOTUS CORNICULATUS AGG.

By

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After having examined the anatomy of the flower parts of 7 wild growing and 3 cultivated *Lotus* taxa, the author presents the characteristic tissue features of the calyx, petals, the pollen and the stamen regions, the pod fruit and the seed coat in the papilionaceous and pentamerous flower whorl.

Introduction

The undertaken investigation on the primordia and development of *Lotus corniculatus*, of its flower structure, the floral parts and their tissue structure in conjunction with the preceding study on the vegetative organs (Borsos, 1971, 1973 and 1975) brings the inquiry on the anatomy of wild growing and cultivated taxa of the bird's-foot trefoil to a conclusion. The present paper summarizes the results obtained and represents the completion of this study series.

Of the pertinent literature, the work of H. W. Hansen (1953) merits special attention who, in a short chapter of his paper, discussed observations made on the taxon *Lotus corniculatus* var. *vulgaris* Koch, with respect to the relational aspects between the development of the floral parts, their embryology and anatomy.

Material and method

Our investigations concerned several wild growing small species, subspecies and varieties as well as convarieties:

Lotus corniculatus L. ssp. *corniculatus* var. *corniculatus*
Lotus corniculatus L. ssp. *corniculatus* var. *dabasenis*
Lotus corniculatus L. ssp. *hirsutus* (Koch) Rothm.
Lotus corniculatus L. ssp. *hirsutus* var. *hirsutus*
Lotus corniculatus L. ssp. *hirsutus* var. *ciliatus*
Lotus corniculatus L. ssp. *hirsutus* var. *pilosus*
Lotus tenuis W. et K.
Lotus borbasii Ujh.
Lotus corniculatus cv. *Wallace*, cv. *Viking*, cv. *Dawn*.

Longitudinal and cross sectional cuts were taken from the young flower shoot ends and buds with the embedding method (SÁRKÁNY and SZALAI, 1966), the preparations were studied under light microscope and photographed.

Discussion and results

The flower structure of the bird's-foot trefoil is papilionaceous. The single flowers are in a capitulum, generally 4—6 flowers building one capitulum. The description of the anatomical structure of the floral organs, set in pentamerous whorls, follows the order of arrangement by proceeding from the outer members toward the inner constituents including the flower axis (see Photograph 8, Fig. 1).

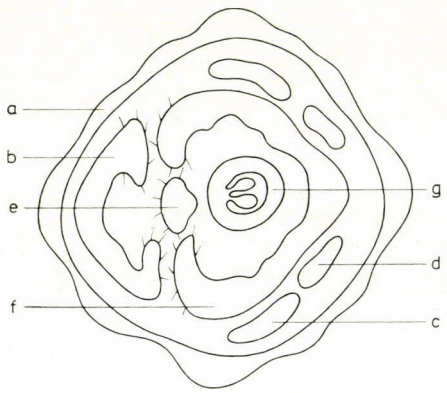

Fig. 1. Diagrammatic drawing of cross section of bird's-foot trefoil flower bud; a = calyx, b = vexillum, c = wings, d = carina, e = tenth filament, f = 9 adelphous filaments, g = carpellum with ovule primordium

1. The axis of inflorescence, when viewed in cross section, appears round or oval. The outer tangential cell walls of the epidermis are thickened, the stomata slightly recessed. Subepidermally, the cortex parenchyma is about 4—5-seriate whose cells are irregularly formed and in the tangential aspect slightly flat. This parenchyma tissue contains intercellular spaces and chloroplasts.

The collateral, open vascular bundles are arranged circularly (cross section), in a central cylinder bordered by a monoseriate sheath of large cells. Between the individual bundles a parenchymatous pith tissue develops whose enlarged cells contain intercellulars.

2. The sepal is similar to the deciduous leaf in tissue structure. The cells of the external epiderm are large, their outer walls incrassate and covered by cuticule. The cell walls (superior view) of the hairy-type bird's-foot trefoil (ssp. *hirsutus*) are slightly sinuous, those of the narrow-leaved bird's-foot trefoil straight. The epidermal cells on the inner side are smaller and tangenti-

ally elongated. Stomata are present on both sides of the epidermis. Between the two epidermal layers is the mesophyll, a spongy parenchyma consisting of polygonal cells with a chloroplast content. The tissue cells are arranged loosely, their surfaces only partially contiguous on account of large intercellular passages and air spaces. Around the main veins the mesophyll is 3—4 seriate, but at most 1—2 seriate between the two epidermal layers at

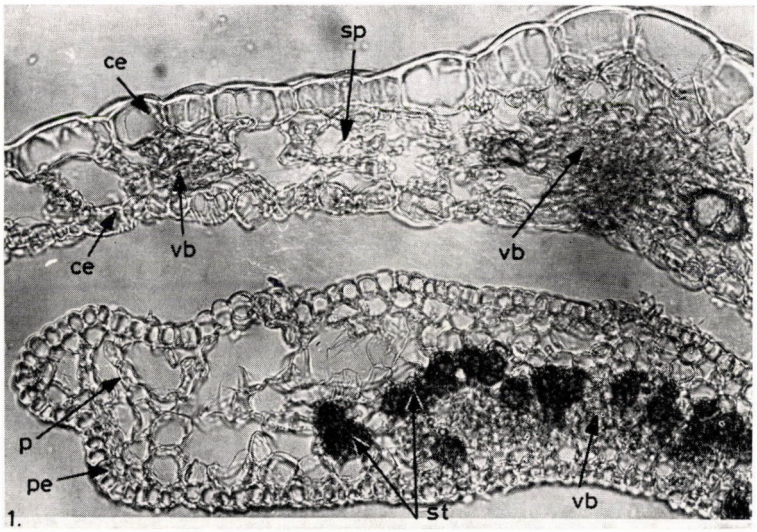

Photo 1. Lotus corniculatus ssp. *corniculatus*, cross section of calyx and petal (3.5×25); ce = calyx epiderm, sp = spongy parenchyma, vb = vascular bundle, pe = petal epiderm, p = parenchyma, st = starchy cells

the parts surrounding the teeth of the calyx. A large number of the mesophyll cells contain starch. The collateral vascular bundles are also in the mesophyll (see Photograph 1).

The sepal structure of *Lotus borbasii* resembles the dorsiventral leaf type. Over the inner side of the epidermis there is a 2—3-seriate palisade parenchyma, whose radially elongated cells are loosly arranged owing to intercellular spaces (see Photograph 2).

3. The epidermal cell of the petals are isodiametrical on both sides of the lamella (see Photographs 1 and 5). Along the border region of the lamina and the claw of the vexillum, on the inner surface and especially on the incurving sides, the epidermal cells are papillose (see Photograph 6). Also papillose is the outer epidermis of the wing of some types (as in the varieties of *L. corn.* ssp. *hirsutus*) (see Photograph 3), furthermore the epidermis of all petals of *L. borbasii* (see Photograph 4). Stomata are absent from the epidermis of all five petals. The mesophyll is 2—4-seriate, and there are numerous intercellular passages between the large-sized polygonal parenchyma cells. The

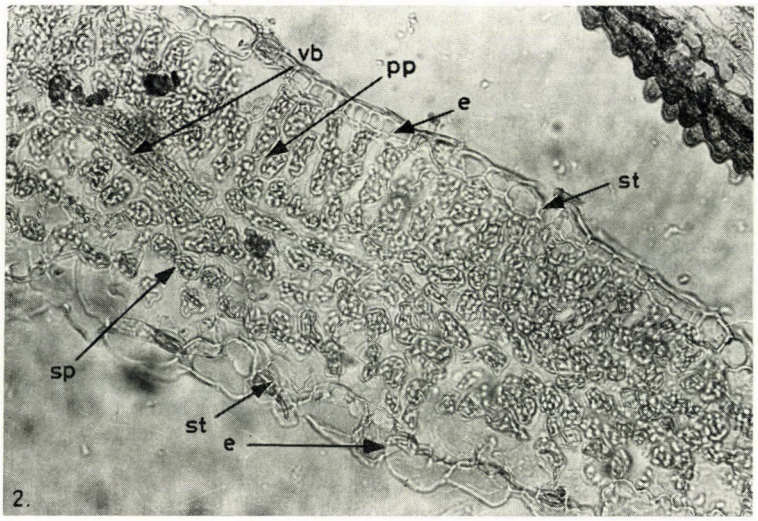

Photo 2. Cross section of *Lotus borbasii*, calyx (3.5×25); e = epiderm, st = stoma, vb = vascular bundle, sp = spongy parenchyma, pp = palisade parenchyma

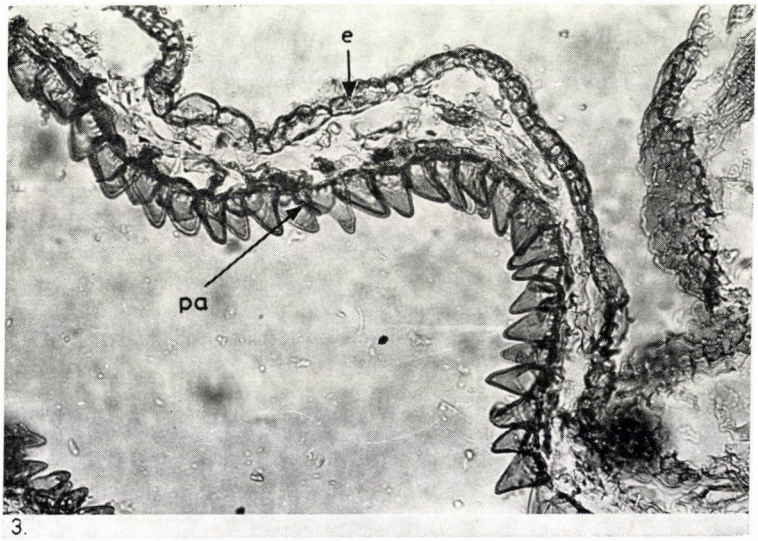

Photo 3. Cross section of the petal (ala) of *Lotus corniculatus* ssp. *hirsutus* (3.5×25): pa = epiderm layer of the outer side with papillae, e = epiderm

mesophyll contains collateral vascular bundles, and cells with a starch content are frequent.

4. The primordia of the 10 stamens arise from the finger-like outgrowths of the reproductive growth apex. In the course of development, first the anther primordium appears, then the growth of the basal parts results in the

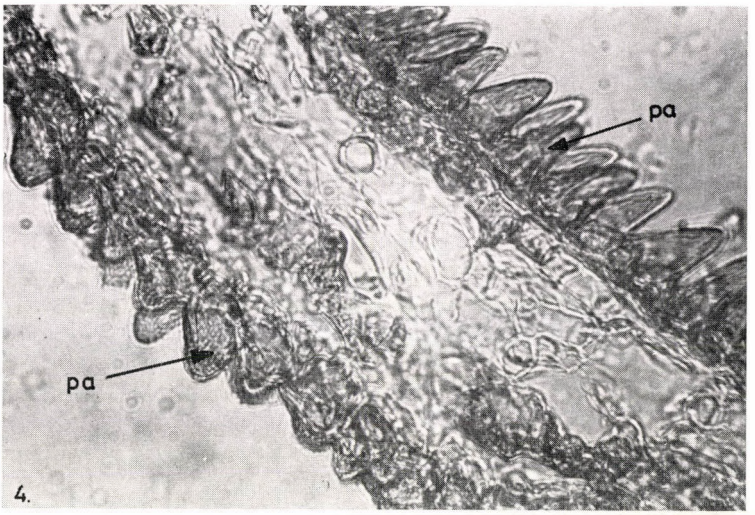

Photo 4. Cross section of the vexillum of *Lotus borbasii* (3.5×40). Epiderm layer of both sides with papillae (pa)

Photo 5. Cross section detail of *Lotus corniculatus* ssp. *corniculatus*, flower with wing and carinate petal (3.5×10); Wie = epiderm of wing, p = parenchyma, vb = vascular bundle, st = starchy cells, ce = epiderm of carina

fusion of the proximal ends of the 9 filaments. The tenth filament remains free between the carpellum and the primordium of the vexillum causing a typical diadelphous arrangement of the stamens. Later the coalesced base of the filaments elongates and surrounds the base of the ovary. The 9 antheras become erect and surround the style. The filament of the tenth stamen also elongates.

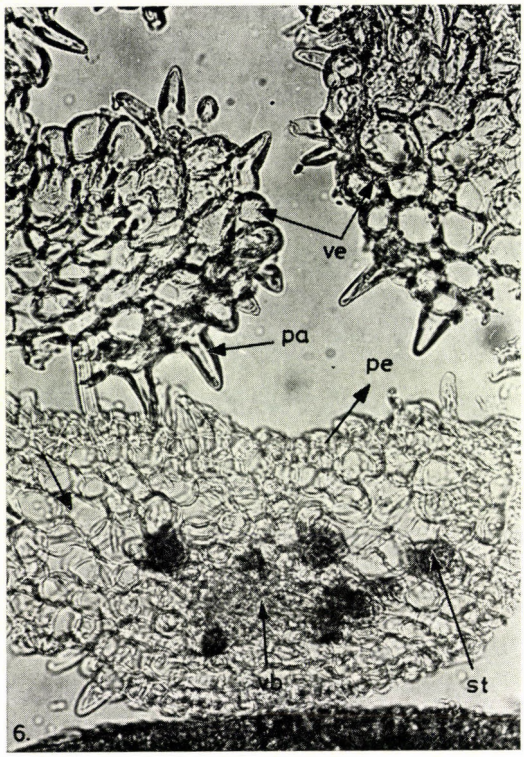

Photo 6. Cross section of *Lotus corniculatus* ssp. *corniculatus* flower: epiderm of vexillum with papillae and of the 10th filament (3.5×25); p = parenchyma, ve = epiderm of vexillum, pa = papillae, pe = epiderm of pollen, st = starchy cells, vb = vascular bundle

The epidermis of the filament is uniseriate, composed of polygonal cells radially, its surface comes out with cuticular incrassation and papillae. Below the epidermis is the 2—3 seriate parenchyma rich in intercellulars, its cells are polygonal and contain starch. There is a single collateral vascular bundle centrally (see Photograph 6).

The tissue elements of the nine diadelphous stamens form an incomplete ring or cylinder. In its cross section, the outer epidermis is sinuously circular, the rectangular cells are slightly elongated radially, their walls are cuticularly incrassate and papillose. The inner epidermal cells are tangentially elongated, smaller and also cuticularly thickened. Below the epidermis of the outer part, there is a single layer of regularly arranged cells followed by a parenchyma tissue of 2—3-seriate larger cells rich in intercellulars. Nine vascular bundles run through this tissue, one bundle per one filament. The xylem of the vascular bundles faces the ovary, the phloem is oriented outwards. The parenchyma tissue (see Photograph 7) contains starch.

The exothecium of the anthers is the uniseriate epiderm with a papillose outer wall. Below this is the endothecium of a peculiar structure. The cells are exceptionally thick, the radial walls being of a ribbed incrassation. Inside are the intermediate layer and the tapetum. Four pollen sacs develop in each. A vascular bundle runs through the connective surrounded by a bundle of parenchyma. On the side next to the adjoining anther, the cells of the separating wall appear. In the course of development, the sporangial wall between the two neighbouring pollen sacs disintegrates and the mature anthers become

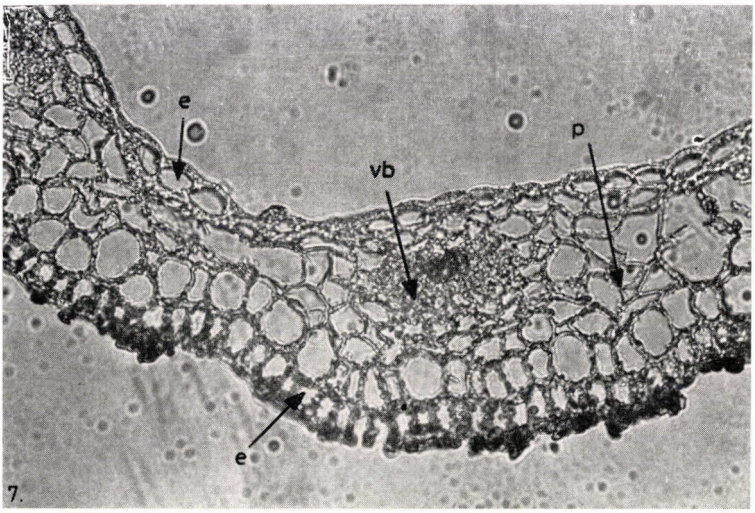

Photo 7. Cross section of the adelphous filament (3.5×25); e = epiderm, vb = vascular bundle, p = parenchyma

two wide pollen cavities per anther. The intermediate and the tapetal layers disappear and the oval binucleate pollen grains are liberated (see Photograph 9).

5. The innermost, conical meristem of the reproductive apex gives rise to the carpel primordia. The carpellum develops from a single carpel. The epidermis consists of quadratic cells with thickened walls, with cuticular cells on its outerpart. Within this, the mesophyll evolves partly from a single well-developed sclerenchymatous cell layer and partly from an inner parenchymatous 4—5-seriate layer. The cells of the latter are polygonal and rather tightly packed with only few intercellular spaces and it contains two large vascular bundle groups at the ventral and one at the dorsal sutures. The innermost epidermis consists of quadratic cells with incrassate walls, though smaller than those of the outer epidermis (see Photograph 10). The primordia of the two anatropous ovules adjoin the ventral suture of the carpel.

6. The wall tissue of the mature pod fruit differentiates as follows (see Fig. 2). Externally, the epicarpium consists of incrassate cells quadratic or

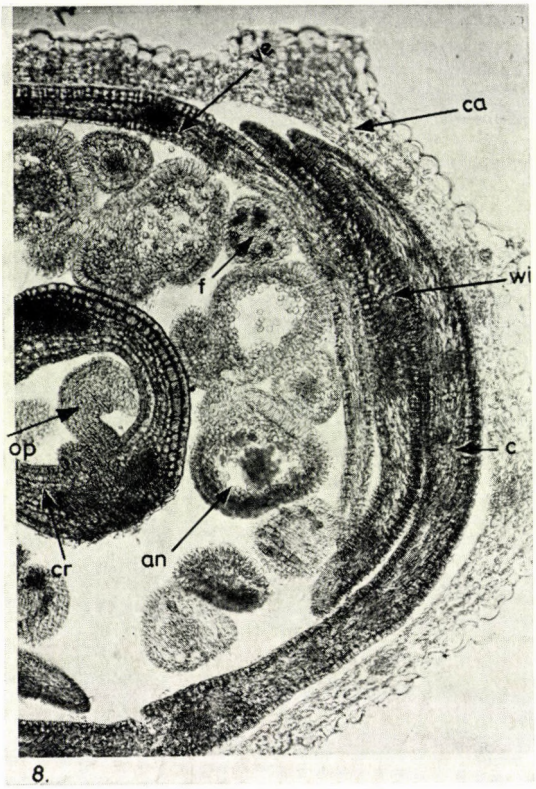

Photo 8. Cross section, detail flower of *Lotus corniculatus* ssp. *corniculatus*, (3.5 × 10); ca = calyx, ve = vexillum, wi = wing, c = carina, an = anthers, f = filaments, cr = carpellum, op = ovule primordium

slightly elongated tangentially, their outer wall is cuticular. Below this, the mesocarp is composed of large, tangentially elongated cells with a broad lumen. Then follows a multiseriate, loose parenchymal zone, rich in intercellular passages and with collateral vascular bundles displaying a diversified decurrence in the carpellar wall, thus, if viewed in a cross section, a part of the bundles shows a longitudinal course. Along the ventral suture and above the two groups of vascular bundles, two sclerenchyma bundles are situated, while oppositely, along the corresponding dorsal suture and above the single large vascular bundle, an elongated bundle of sclerenchyma is located. The two groups of vascular bundles of the ventral suture and the single group of bundles of the dorsal suture — the main vein of the carpel — have originated from the fusion of several collateral vascular bundles. At the inner side of the mesocarp, the parenchymal zone joins the multiseriate fibrous sclerenchyma by radially considerably elongated cells. These fibrous layer cells with heavily thickened walls attenuate (in a cross section) at the dorsal and

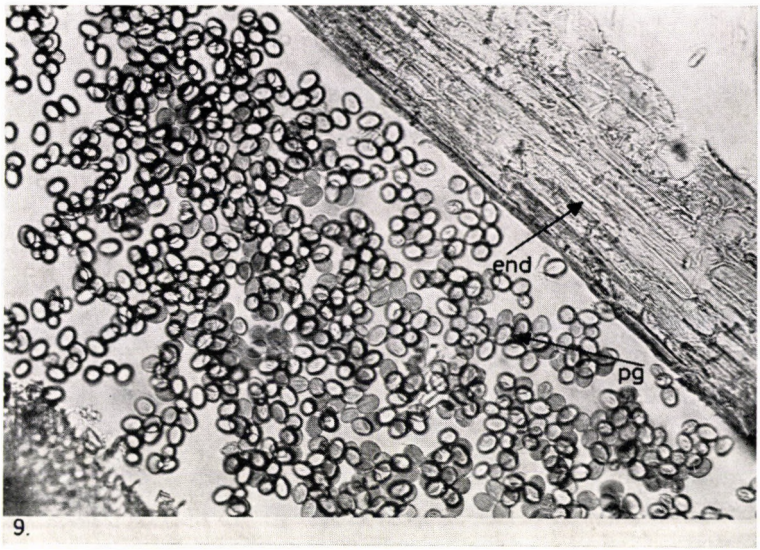

Photo 9. Longitudinal section of binuclear pollens (3.5 × 25); end = endothecium, pg = pollen grains

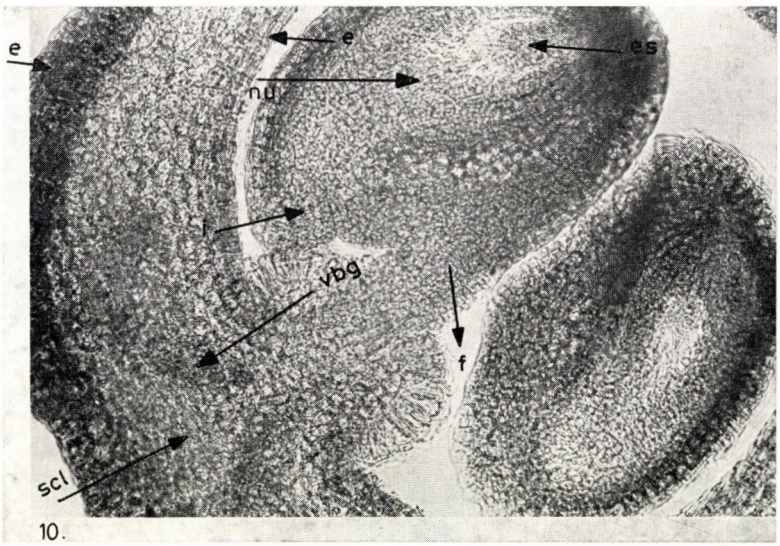

Photo 10. Cross section, detail of carpellum with ovule primordium (3.5 × 25); i = integumentum, f = funiculus, nu = nucellus, es = embryo sac, e = epiderm, scl = sclerenchyma bundle, vbg = group of vascular bundles

ventral sutures. The internal space of the pod is filled out by the spongy parenchyma tissue, the seed pad, whose cells surrounding the ovule primordium are radially considerably elongated. In the innermost region the endocarp is uniseriate, with a papillose surface.

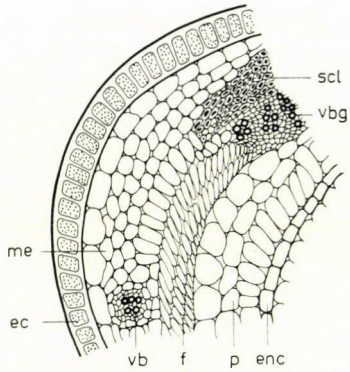

Fig. 2. Cross section, drawing of fruit wall of bird's-foot trefoil (120×); ec = epicarpium, me = mesocarpium, scl = sclerenchyma bundle, vbg = group of vascular bundles, vb = vascular bundles, f = fibrous layer, p = internal parenchyma layer, enc = endocarp

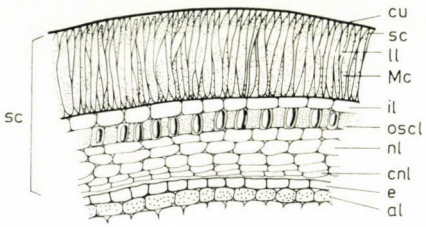

Fig. 3. Partial view of cross section of seed coat of bird's-foot trefoil (240×); cu = cuticule, sc = subcuticule layer, ll = light line, Mc = Malpighi cells, il = intermediate layer, oscl = osteosclereid cells, nl = nutrient layer, cnl = collapsed nutrient layer, e = epiderm, sco = seed coat, al = aleuron layer

7. The seed. The cuticule of the testal epiderm is rather thick and consists of pectin and cutine (WATSON, 1948). The subcuticular layer of the epiderm forms the apical part of the suberine Malpighian cells and contains cellulose. The light line is a transparent thin cutine bundle, allowing a view of the longitudinal walls of the Malpighian cells. Below the light line, the Malpighian cells are dark yellow, elongate, small in diameter and slightly intermixed, their slit-like lumina broaden basally. This area is followed by the supporting (intermediate) layer, composed of large, light, quadratic or polygonal cells with cuticular walls. The uniseriate osteosclereid cells are wide, light, thickened with pectin and cellulose, and displaying narrow intercellular spaces. Next is the multiseriate parenchyma, the so-called nutrient layer whose cells are externally large, wide and light, internally smaller and compressed (see Fig. 3).

The epiderm of the two embryonal cotyledons consists of tangentially slightly elongated cuticular cells.

Within the epidermis is the uniseriate and partly fragmentated aleuron with cellulose content. Intercellular passages appear between the cells of the

mesophyll. The radicle, hypocotyl and plumule of the embryo show a meristematic tissue structure at rest. The hilum appears as a small protuberant round spot in deep recess bordered by the slightly concave apex of the radicular primordium. An elongated deep pit at the umbilical aperture is bordered by the elevated margin of the light-coloured suberine cells. This deep aperture is regarded by a number of authors as representing the split of the cotyledons. The remnant of the micropyle is a small semicircle opening, adjacent to the orifice of the hilum. By way of the hilum vascular bundles are decurrent to the embryo.

Summary

The present paper sums up the results of investigations on the tissue differentiation of the floral parts and the floral shoot apices of 7 wild and 3 cultivated *Lotus* taxa.

The anatomical architecture of the floral parts display only slight differences among the various taxa as opposed to the vegetative plant parts. Differences are primarily observable in the structure of the calyx and, to a lesser extent, in that of the petals between the wild and cultivated taxa of *Lotus corniculatus* ssp. *corniculatus* as well as of the hairy ssp. *hirsutus* taxa and *L. borbasii*. Between the anatomical structures of the stamen and the anther regions no qualitative difference could be observed among the taxa studied.

The pentamerous flower whorl of the papilionaceous flowers characterizes also bird's-foot trefoil. The tissue structure of the calyx resembles that of an isodiametrical deciduous leaf, the calyx of *L. borbasii* is dorsiventral. The petals and primarily the vexillum are papillose in the three varieties of ssp. *hirsutus* and the outer epidermic layer of the vexillum and all the petals of *L. borbasii*. Stomata are absent from the epiderm of the petals, cells containing starch are frequent in the mesophyll. The structure of the 9 adelphous filaments differs from that of the tenth filament; 9 vascular bundles run through the mesophyll. The cross section of the anthers exhibit a ribbed incrassation in the radial cell walls of the endothecium. The pollens are binucleate. The anathropous ovule primordium develops into the single carpel. The collateral vascular bundles of the pod fruit in the mesocarp developes into a single or two large vascular bundle groups at the corresponding ventral and dorsal sutures. Above them sclerenchyma bundles appear. The tissue structure of the seed coat is characterized by the epidermal cell cuticule containing pectine and cutine, the cellulose content of the suberine Malpighian cells, the rows of osteosclereid cells thickened by pectine and cellulose, and the multiseriate parenchyma: the nutrient layer.

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ECOLOGICAL OBSERVATIONS ON THE AQUATIC HYPHOMYCETES OF HUNGARY I.

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The present paper communicates data on the proliferation of aquatic Hyphomycetes in the montane Morgó stream (Mts Börzsöny) and on some communities of species attributable to certain ecological factors. The collected data are based on studies conducted for several years. There are two well distinguishable communities with respect to the locus of occurrence. Observations disclose that one of the chief determinants is the substratum preference of some fungus species. Data are also furnished on aquatic hyphomycetous species whose seasonal appearance is closely related to the annual development of water temperature and to fallen leaves.

Introduction

It is a well known fact that aquatic Hyphomycetes grow on leaves, twigs and other decaying plant parts submerged in water. The mycelium developes in the decomposing tissue while the conidiophores develop on the surface of the substratum and spill the conidia into the water.

Aquatic Hyphomycetes, together with other organisms, play a role in the decomposition of plant parts primarily of tree leaves submerged in water. This role, however, has not been adequately studied so far and therefore little is known about it. It is also recognized that fungi are present mainly in clean, oxygen-rich river water (e.g. in mountain streams) and that conidia will, after having been spilled into the water, collect in the foam. Investigations by IQBAL and WEBSTER (1973a) revealed that the relation between quantity and the species composition of the spores of aquatic Hyphomycetes found in foam samples do not reflect true ratios present in the natural aquatic environment. Data by analysis of the foam samples are therefore not a satisfactory contribution in obtaining a clear picture about conglomerates of aquatic Hyphomycetes in the mountain stream system under discussion; furthermore, in some instances these data may even result in erroneous conclusions.

Considering these findings, confirmed also by my own observations, it is my intent nevertheless to report observations which were based mainly on foam sampling analysis. For I am convinced that the method of foam analysis yields valuable data which brings us closer to the proper understanding of the proliferation of aquatic Hyphomycetes and their seasonal frequency of occurrence although the method is by no means free of inherent deficiencies.

Material and method

In an earlier paper (1971) I reported that in the stream system (Morgó Stream in the Mts Börzsöny) the conidia of some aquatic hyphomycete species are to be found in the foam of the stream only at certain sections and only in certain periods of the year. The report was based on the investigations of several years during which time foam samples were collected mensually. Subsequent investigations along the same lines of inquiry confirmed previous findings and contributed additional data. Next to foam analysis some species were grown in an aquarium and it was found that the occurrence or non-occurrence of condia of some fungi along certain sections of the stream is not an incidental event but a phenomenon of strict consequence.

The following simple method has been employed in the analysis. At sections of the stream where the conidia of some species occurred frequently in the foam submerged leaves of various tree species in various stages of decay have been collected. Several small-sized aquaria as well as glass containers were filled with water taken from the stream and the sample leaves placed into the vessels. By means of an atomizer, air stream was constantly admitted to the water.

Intensive conidia production have usually started after 5 to 10 days. Sporulation was most intensive in leaf cultures which contained leaves collected in the winter and whose water temperature was kept at about 5 °C. Observation of sporulation in the culture ran concurrently with foam sample analysis. The following conclusions were reached.

Characterization of the analysed habitat

The bed of the Morgó stream and of all its tributaries consist of vulcanic, eruptive rock (andesite). The greatest distance in the stream system is 20 km between the extreme points of the estuary and the spring of the Szén Stream. With the exception of a few sections, the stream is a precipitous rapid current and its bed is composed almost everywhere of rocks. This holds especially for its upper reaches where the stream runs in a gorgem its banks free of vegetation (Fig. 1). The valley of the gorge is overgrown by *Fagus silvatica* woods mixed with *Carpinus betulus*, while at higher elevations *Quercus*, *Fraxinus*, and *Acer* species can also be found (see Fig. 2 and map). The main part of the leaves falling into the stream derives from *Fagus silvatica* and *Carpinus betulus*. Less significant is the leaf portion supplied by other tree species.

At the entrance of the gorge the valley widens and *Fagus* and *Carpinus* are abruptly replaced by *Alnus glutinosa*, hemming in the stream as far as its mouth (see Fig. 3) *Salix* and *Populus* species are represented by locally larger stands. Along the lower reaches shrubby communities (*Sambucus nigra*, *Corylus avellana*, *Acer* sp.) chequer the vegetation of the banks.

Stream temperature during the year changes according to the following time pattern. In December and January, water temperature is between 0—1 °C. In February and March, temperature does not exceed 1—4 °C. Temperature begins to climb in April and in the second half of the month it may rise above 10 °C. At the same time, great temperature fluctuation characterizes the water for April and May (7—15 °C). During the summer months, temperature is relatively high and remains at a constant level (June through September around 18 °C). In September and October, temperature drops below 10 °C; from October it gradually approaches winter values.

Results

Distribution of the species in the stream system

During the course of earlier observations it was assumed that the existing differences between the species composition of aquatic Hyphomycetes at various stream sections are most probably due to the quantitative and qualitative composition of the leaf substratum present in the water. Similar observations were reported by IQBAL and WEBSTER (1973/b) on the aquatic Hyphomycetes found in the stream of the Exeter region. According also to these

Fig. 1. Upper reaches of the Morgó Stream in the beech region

authors some species of aquatic Hyphomycetes show preference for the leaves of certain tree species.

My studies made in the Morgó stream system point indicate that the composition of the stream bank vegetation and changes in the composition along the stream determine the composition of aquatic Hyphomycetes in the respective habitat or, at least, the frequency of occurrence of some species.

In the upper reaches of the stream (see map sketch Fig 2) the mass of the submerged leaves is contributed by *Fagus silvatica* and *Carpinus betulus*. Occurrence of the *Quercus* leaf is very rare and the leaf ratio of the other species is even lower. Of the two species characterizing the upper section (*Dactylella aquatica* and *Monotosporella tuberculata*), the former occurs more frequently on the *Fagus* leaves, at times in masses (see Figs 4—5).

The latter yields spores copiously both on *Fagus* leaves and also on *Quercus* sp., *Carpinus betulus*, *Tilia* sp. (Figs 6—7). The abundant representation of conidia of both of these species in the foam can be explained on the

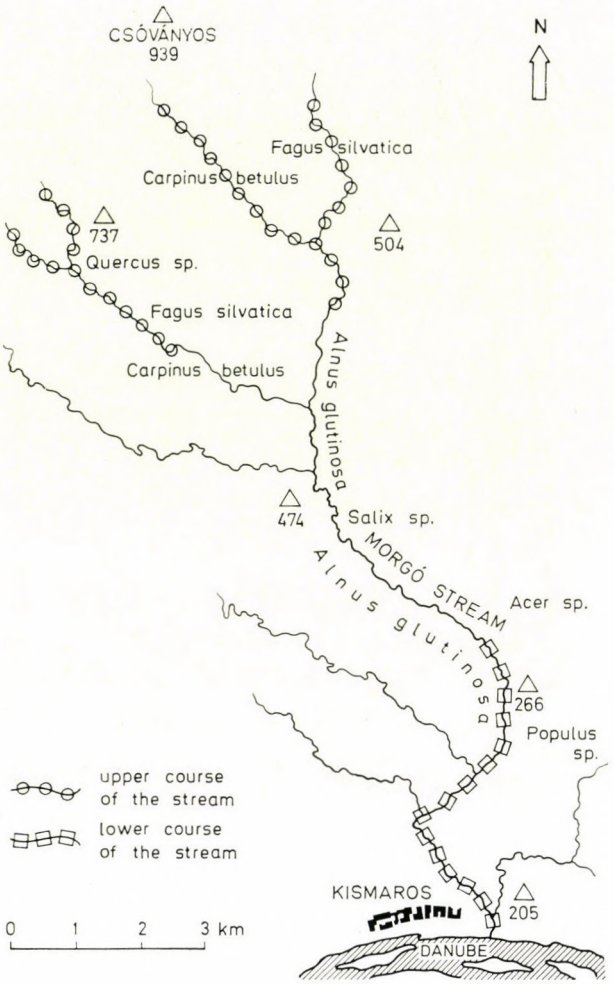


Fig. 2. Sketch map of the stream system, with the most frequent plant species along the banks

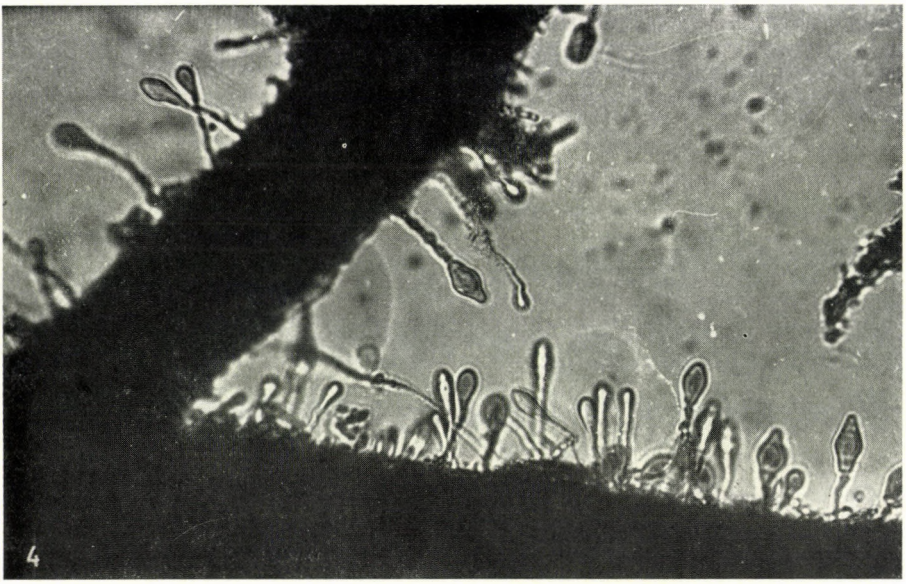
basis of substratum preference. Since *Fagus* leaves are uncommon in the lower reaches, this might well be the reason of the absence there of *Dactylella aquatica* and *Monotosporella tuberculata*. Although *Quercus* leaves occur more frequently than *Fagus* along the lower reaches, *Monotosporella tuberculata* could not be found, even though it was concurrently frequent on leaves in the upper reaches.

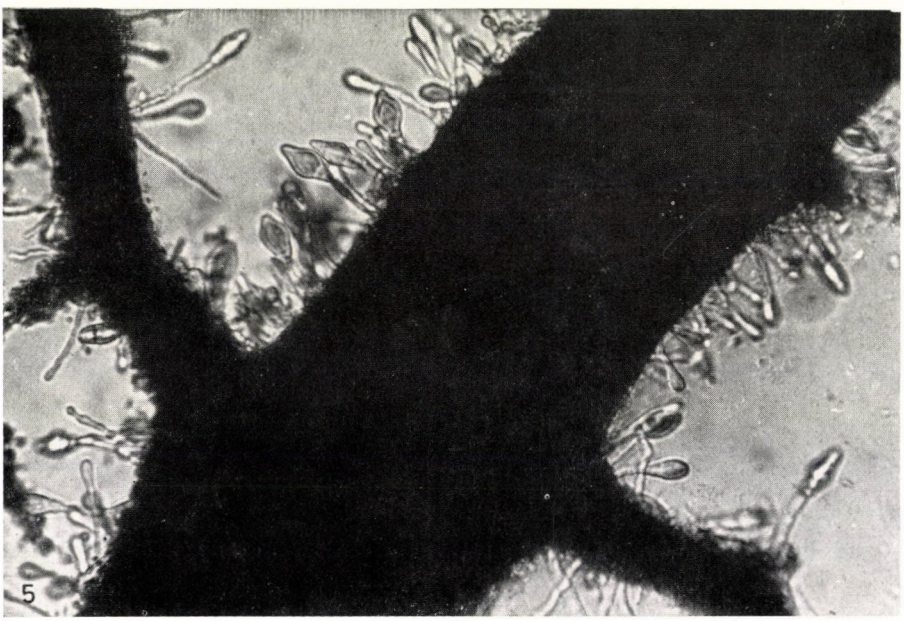
This raises the question on the role of the other ecological factors besides the various types of substratum, and by the same token it invites care with respect to the acceptance of criteria upon which substratum preference of a given species is judged. In case of *Dactylella aquatica* and *Monotosporella*

Fig. 3. Lower reaches of the Morgó Stream in the *Alnetum*

tuberculata, culture experiments have corroborated the inferences drawn from the analysis of foam samples. At the same time it has also been proved that the quantitative relations of some species present in the foam are not true reflections of the actual values. Although conidia of *Dactylella aquatica* characterize the upper reaches their quantitative representation in the foam is relatively low. At the same time, however, conidia develop in great numbers on *Fagus* leaf fragments collected here (Figs 4—5). Several hundreds of conidia may be present along 1—2 cm length of a leaf-vein while only a small portion of the conidial mass accumulates in the foam.

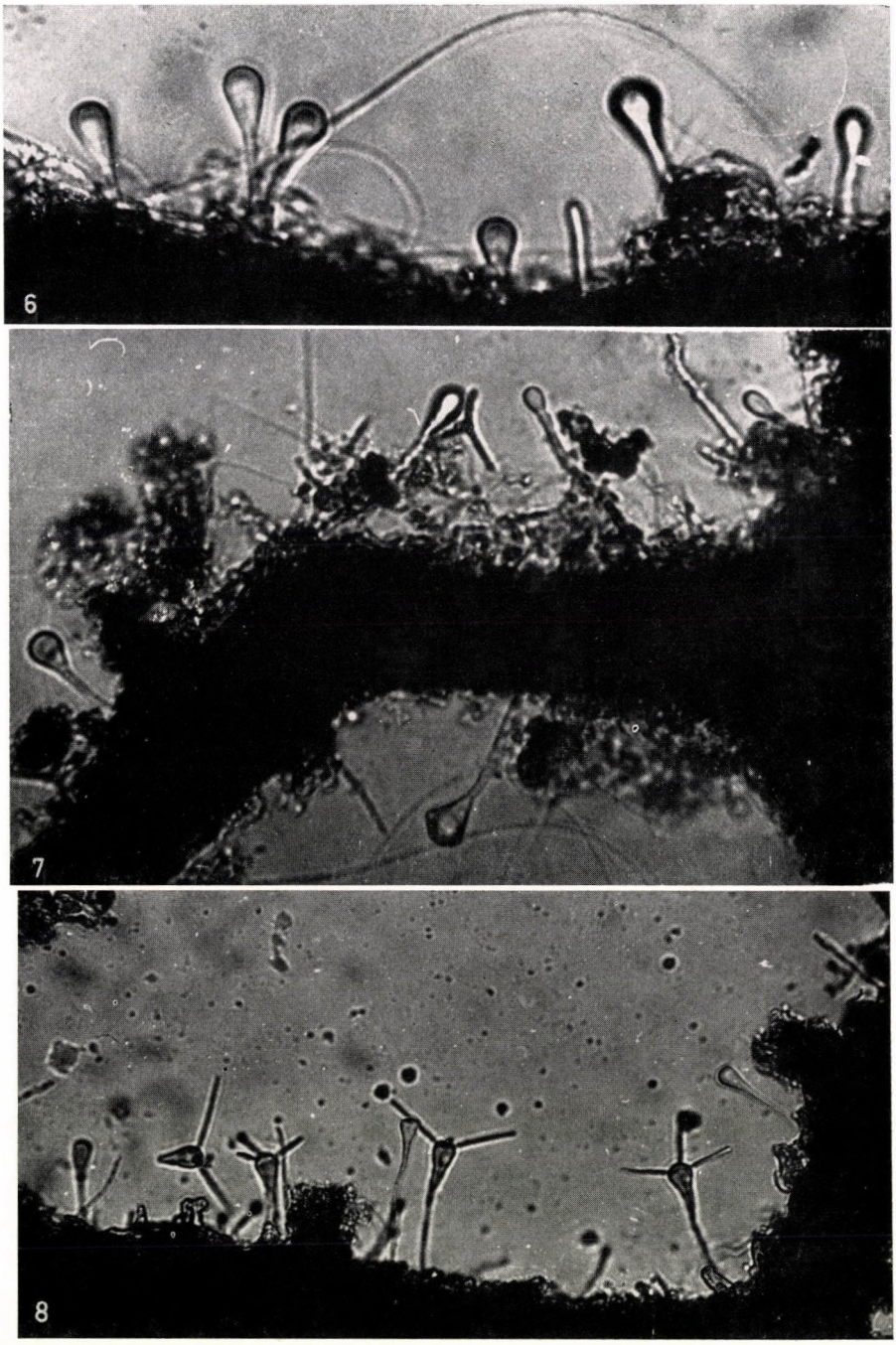
In contrast to the species cited above, conidia of *Monotosporella tuberculata* develop on leaves more sparsely and in smaller numbers (Figs 6—7), but their occurrence is more frequent in the foam than that of *Dactylella aquatica*. This difference is probably partly related to the affinity of the conidia to air bubbles (the smooth-surfaced conidia as compared to the rough-surfaced conidia).





Figs 4—5. Copiously sporulating *Dactylella aquatica* on the veins of skeletal *Fagus silvatica* leaves collected in the upper reaches, (200×)

Unfortunately, I have insufficient culture results for an adequate explanation of the occurrence here of species frequent at the lower reaches. Major portion of the submerged leaf material at this section is contributed by *Alnus*



Figs 6—7. Sporulation of *Monotosporella tuberculata* on skeletal *Fagus* and *Quercus* leaves collected in the upper reaches, (330×)

Fig. 8. Sporulation of *Clavariopsis aquatica* on *Fagus silvatica* leaves collected in the upper reaches

glutinosa. The species frequent and at times appearing in masses (e.g. *Tricladium angulatum*, *Tetracladium marchalianum*) along this reach were seen only one or two times to grow on *Alnus*, *Quercus* and *Acer* leaves, and then only in relatively small numbers and never in masses as found in the foam samples.

In the followings, I indicate the occurrence of some species along the stream on a map (Figs 10—15). As we proceed from map to map the changes taking place in the course of the year can also be braced. I have not indicated the conidia of all species occurring at a given section at a given time. The graphical signaling of conidia at the lower and upper reaches signifies the most characteristic species present during a given season at the particular stream section, as indicated by the collected foam samples. The foam samples which served for the basis of comparison were collected at the lower and upper reaches on the same day. It is unfortunate that data on the well distinguishable reaches, distinct also by the occurrence of conidia, to allow inferences on how far the conidia of some species travel downstream and on the degree of transition into the species community of the lower reaches.

In the case of a rapidly flowing mountain brook like the Morgó Stream one might expect that the great portion of conidia liberated at the upper reaches would be transported far downstream. However, my investigations disclosed that the conidia of species frequent at the upper reaches are not transported too far from their original point by the current. E.g. conidia of *Dactylella aquatica*, *Monotosporella tuberculata*, and of *Anguillospora crassa*, characteristic of the upper reaches, occur only in restricted numbers in foam samples taken 3—4 km downstream, while they are practically absent from the samples taken at the lower reaches.

I mention 4 spores characteristic of the lower and the upper reaches, respectively, which are not known among the aquatic Hyphomycetes, but their regular occurrence in a given period or at a given place is characteristic. They are as follows:

a) *Monotosporella tuberculata* Gönczöl
b) Tetraradiate conidium (probably *Clavatospora* sp.?)
c) Triradiate conidium, Y-shaped
d) Tetraradiate organism (its fungal origin is not certain) (Fig. 9).

January—February (Fig. 10)

Upper reaches: *Monotosporella tuberculata* occurs the most often, amounting to about one half or more of the total conidia. Similarly, the conidia shown in Fig. 9/b are also frequent, appearing mostly together with those of *Alatospora acuminata*. Characteristic to this period are some quadriradial conidia present in great numbers (*Lemonniera aquatica*, *L. terrestris*, *Articulospora tetracladia*), although less abundantly than the two preceding species. *Dactylella aquatica* occurs less frequently.

Lower reaches: Of the previous species, *Monotosporella* absent from the conidial community, only one or two representatives, at the most, can be found per foam samples *Lemonniera aquatica* and *L. terrestris* appear more frequently, but the tange of frequency characteristic to the upper reaches was approximated only once during the entire period of investigation. However, *Tricladium angulatum* occurs in greater quantities, entirely absent from the

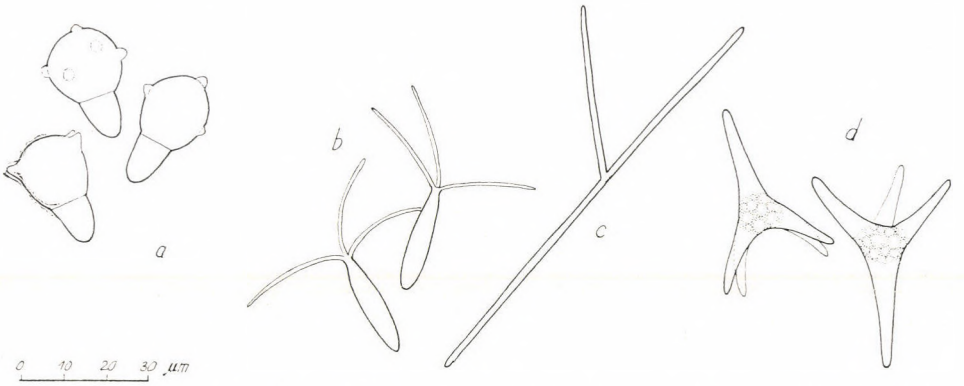


Fig. 9. Conidia from the Morgó Stream: a) *Monotosporella tuberculata* Gönczöl; b) Tetraradiate conidium (*Clavatospora* sp.?); c) Triradiate conidium; d) Tetraradiate organism (its fungal origin is not certain)

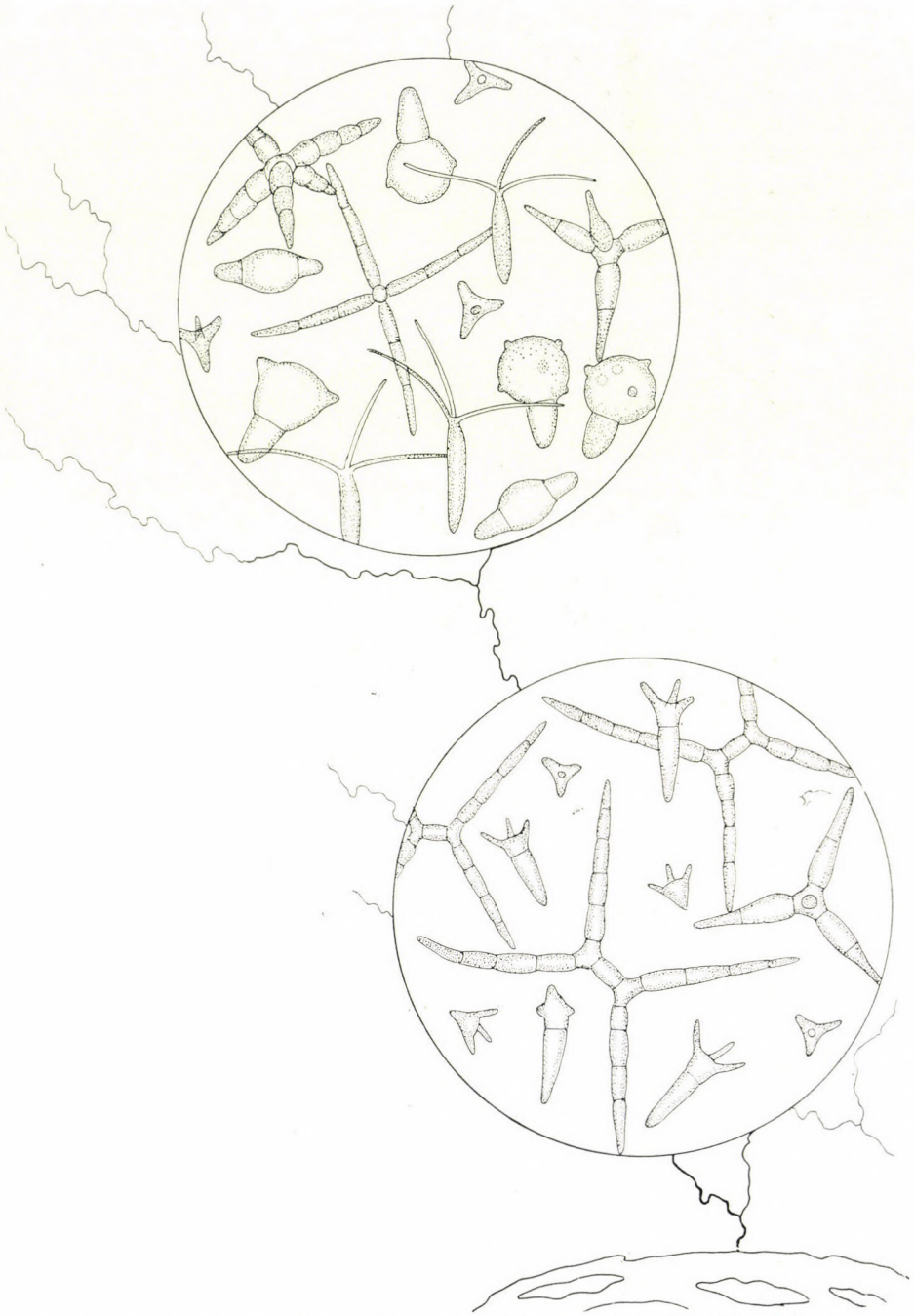
upper reaches. Here it amounts to 1/3 of all conidia. About the same ratio of occurrence is shown by *Clavatospora stellata*, present also at the upper reaches but more infrequently.

Conidia of *Heliscus aquaticus* also appear frequently, with a frequency similar to that of *Tricladium angulatum*. On some occasions, I found it in outstandingly high ratios (20—50% of all conidia in the February samples of 1970—1972).

March—April (Fig. 11)

Upper reaches: the conidia of *Monotosporella tuberculata* can still be found in large quantities, but *Anguillospora crassa* characteristic of the spring species community also appears. Earlier it was represented only by one or two spores in the foam samples. The multiple-branched conidia, less frequent than the preceding two species, appear about this time, they most probably belong to *Speiropsis irregularis*.

Lower reaches: the frequency of occurrence of *Tricladium angulatum* and *Heliscus aquaticus* remains about the same as in the previous month. This period is characterized by *Tricladium gracile* and the Y-shaped conidia resembling those of *T. gracile* (Fig. 9).



Characteristic conidial associations at the upper and lower reaches of the Morgó Stream during different periods of the year (Figs 10—15). *Fig. 10.* January—February

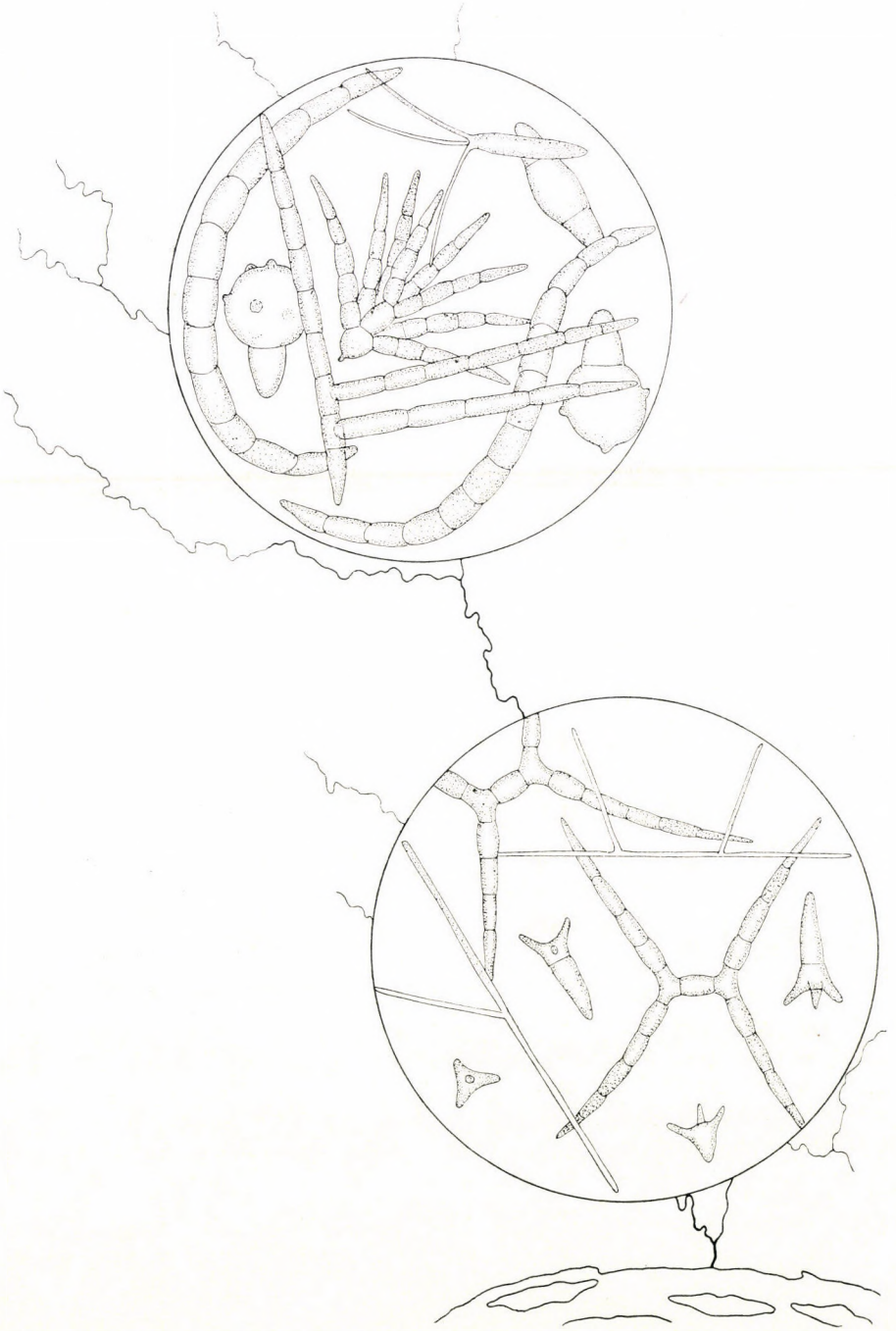


Fig. 11. March—April

The number of the *Clavatospora stellata* conidia diminishes, buth their absence becomes conspicuous only in the samples collected in April.

May—June (Fig. 12)

Upper reaches: the dominant species are *Anguillospora crassa* and *Monotosporella tuberculata*. The quantity of conidia of *Tricladium splendens* is significant, as well as a *Heliscus*-like organism (conidia?) which, according to observations made for several years, appears in the foam about this time (Fig. 9d).

Lower reaches: the most strinking change in the conidia community is the complete disappearance of *Clavatospora stellata* (in June) and the increasing numbers of *Tetracladium marchalianum* (chiefly in June).

July—August—September (Fig. 13)

Upper reaches: during these three summer months the conidia of all species found so far are represented in the foam samples, but in smaller individual numbers. Especially the conidia of *Monotosporella tuberculata* decrease as compared to winter counts.

At the same time the predominant two species of the summer conidia community of the lower reaches are *Tetracladium marchalianum*, occurring in masses (sporulation maximum is in August and September), and *Clavatospora tentacula*, appearing punctually in July.

October (Fig. 14)

The stream is affected by two significant changes: water temperature drops significantly (below 10 °C) and leaf deposition commences. Conidia found in both lower and upper reaches occur in great numbers.

Upper reaches: *Monotosporella tuberculata* can be found again in masses and *Anguillospora crassa* is still rather frequent. Concurrently, *Lemonniera aquatica*, *L. filiforme* and *Flagellospora curvula* constitute the major conidia mass in one of the tributaries.

Conidia of *Margaritispora aquatica* also appear in greater numbers in the foam samples about this time.

Lower reaches: *Tetracladium marchalianum* is still frequent, there are many *Tricladium angulatum* and *Flagellospora curvula* still appears in masses.

November—December (Fig. 15)

Upper reaches: *Lemonniera aquatica*, *L. terrestris*, a tetraradiate conidium (Fig. 9b; observed in the January and February community), as well as *Monotosporella tuberculata* occur characteristically in approximately identical proportions. The conidia of *Margaritispora aquatica* occur also relatively frequently.

Fig. 12. May—June

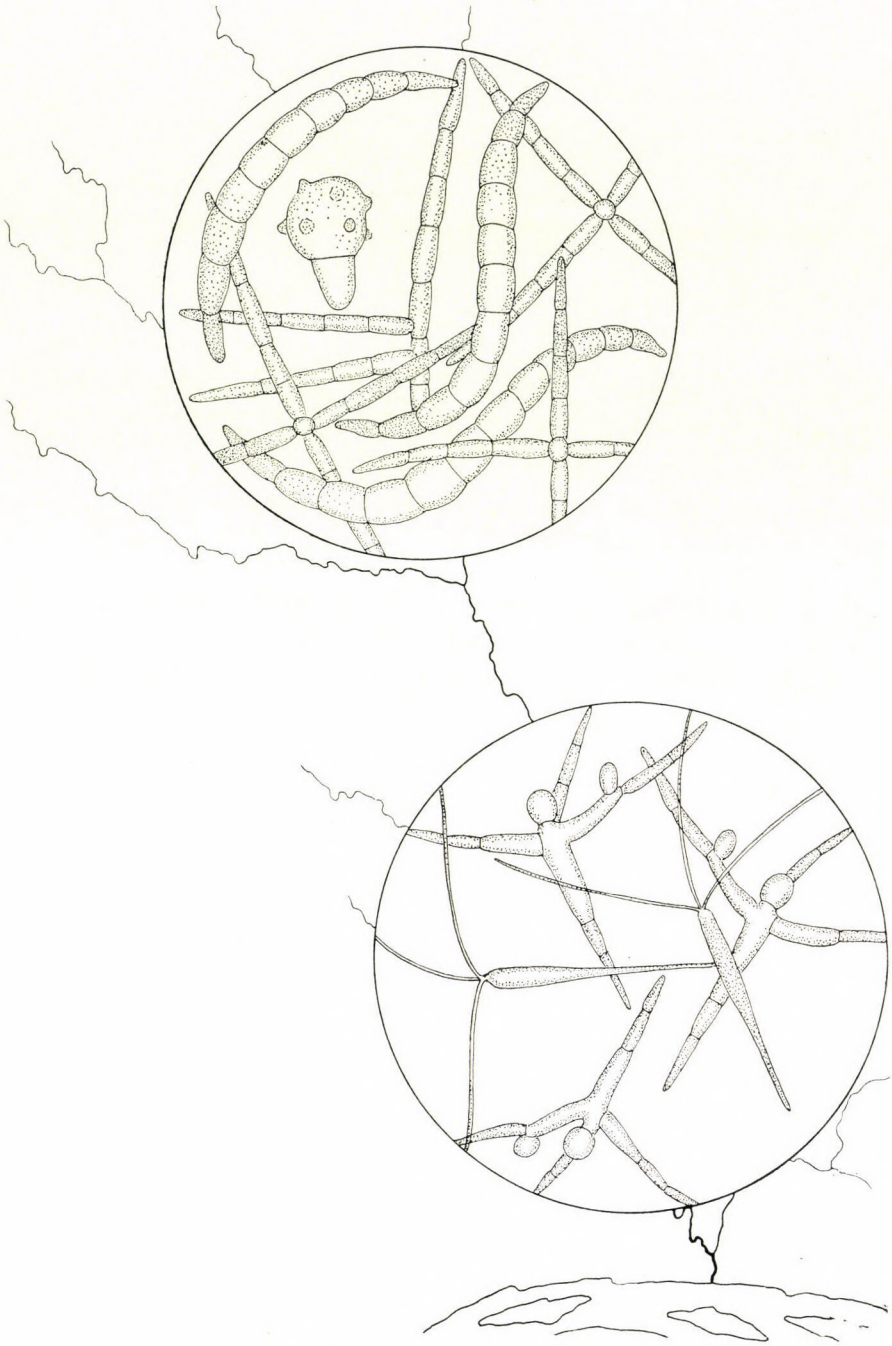


Fig. 13. July—September

Fig. 14. October

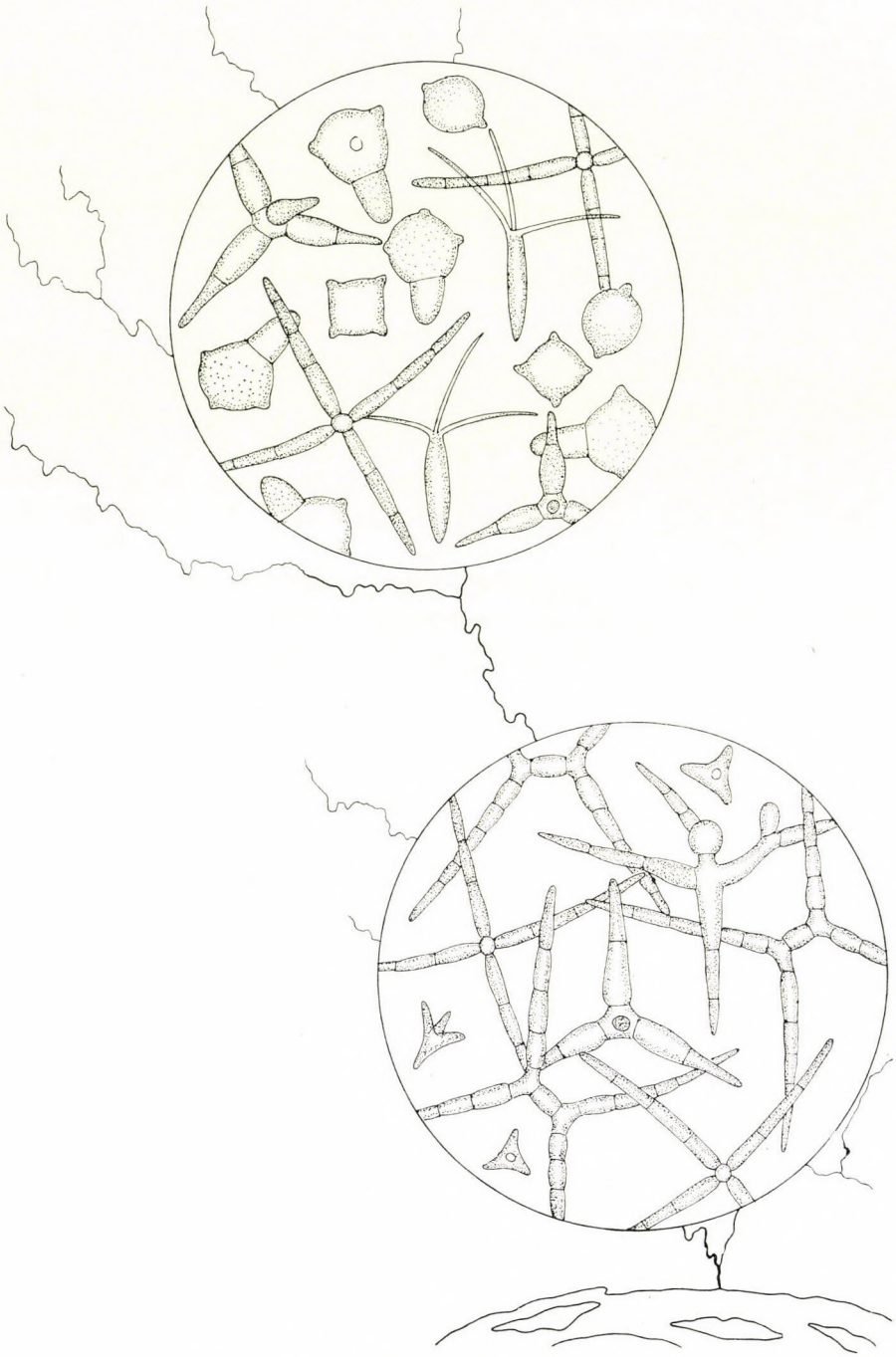


Fig. 15. November—December

Lower reaches: the conidia of *Tetracladium marchalianum* diminish sharply, but *Tricladium angulatum* is still frequent. *Clavatospora stellata* appears in November and becomes more frequent in December.

Unfortunately, I have few data available on other stream systems for justifiable comparison. Nevertheless, the sporadic data imply that changes in the vegetation of the stream banks are followed by qualitative and quantitative changes in the species community of aquatic Hyphomycetes.

The aquatic Hyphomycetes community in another stream of the neighbouring Mts Pilis differed conspicuously from the specific distribution and range pattern discussed so far. The most striking difference was the presence of the same specific conidia, but in a wholly other composition. In a foam sample taken at a single point I found an association of conidia of species which never appeared together in the Morgó Stream (*Tetracladium marchalianum*, *Tricladium angulatum*, *Monotosporella tuberculata*). These three species are invariably disassociated in the Morgó Stream: the first two in the lower reaches the third in the upper reaches (see maps). The composition of the woody vegetation along the stream bank was also different. The stream banks of the investigated section of several kilometers are dominated by *Quercus* sp. constituting the major portion of leaves, and not occurring in such high proportions along the Morgó Stream.

This and some other sporadic investigations support in my opinion the hypothesis that the specific and quantitative composition of aquatic Hyphomycetes participating in the decomposition of leaf litter is the function of the stream bank vegetation.

Seasonal occurrence

Besides distribution in the water, the maps also portray seasonal change in the species communities of the stream. In the course of my investigations it was not my purpose to establish exact numerical ratios of the individual species, but the frequency by which their conidia (masses, sporadic, rare) can be found in foam samples and how these proportions change during the year. Even if the foam samples do not exactly reflect the actual quantitative ratios in the water, they do represent — in my opinion — the trend of changes.

My observations, although based on the analysis foam samples, corroborate this statement since they are in many cases greatly similar to the results obtained by analyses of water samples made by IQBAL and WEBSTER (1973/b).

These authors (1973/b) state that the sporulation peaks of numerous aquatic Hyphomycetes coincide with the autumnal leaf deposition of deciduous trees, while there are some species whose sporulation peaks fall in other

periods of the year. In the followings, I discuss some species which exhibit similar life histories.

IQBAL and WEBSTER (1973/b) state that "The abundance of spores of *Clavariopsis aquatica* and *Flagellospora curvula* show a good correlation with the period of leaf deposition (August through September)". In the course of my investigations I observed that the occurrence of *Clavariopsis aquatica* is unpredictable, although there were years when I could observe a sporulation peak at the end of the winter season and in the spring (Fig. 8) (March through May) as well. Conversely, the sporulation peak of *Flagellospora curvula* in four successive years (1970—73) occurred in October, the most intensive period of leaf deposition. The amount of its conidia at that time equalled approximately half of all conidia. Later its quantity significantly dropped and in subsequent months the conidia occurred only sporadically. A secondary considerably smaller sporulation peak could be observed in February—March.

It was established concerning *Tricladium gracile* that it is not a primary colonizator, its sporulation peak does not coincide with autumn leaf deposition, and that its conidia can be found in greater quantities only in December through April (IQBAL and WEBSTER, 1973/b). I have observed the same phenomenon with respect to material found in Hungary: for several successive years *Tricladium gracile* appeared in samples collected in February, samples collected in March contained ample conidia, but later only some specimens occurred. Rarely did one or two conidia occur during the following months.

A species must be mentioned whose conidia frequency displayed the high degree of regularity with respect to annual changes (1969—1974). This is *Clavatospora stellata* whose seasonal change of frequency showed a fine correlation with changes in substratum and in water temperature.

According to my investigations, *Clavatospora stellata* is definitely a winter species whose sporulation is stimulated by low water temperatures (1—5 °C). There is no obvious variance in the frequency of its occurrence between the lower and upper reaches, but it is always more frequent in the lower reaches. It is the most frequent during the winter months (December through March), beginning April it becomes rarer and from June—July till October it becomes a very rare constituent of the conidial community. I have found no conidia as a rule in these months. It reappeared in samples collected by the end of October and in November, and became increasingly more frequent in the progressively cooling water. This seasonal pattern is depicted by the graph (Fig. 16) where the changing numbers of conidia of *Clavatospora stellata* during the year is plotted against the per cent ratio of total conidia.

It is interesting to note that the conidial production of *Clavatospora stellata* follows the water temperature fluctuations so sensitively that during temperature drops in May — by no means a rare event in Hungary — the April decrease in spore numbers is suspended, indeed it can even increase

temporarily. This is illustrated also by the break in the declining branch of the curve.

An entirely different picture is presented by the course of the annual production of *Tetracladium marchalianum*, one of the most widely spread members of aquatic Hyphomycetes and one of the commonest species also in the Morgó Stream, but — as mentioned in an earlier paper (GÖNCZÖL, 1971) — only in the lower reaches. In the upper reaches of the stream system, in the beech — hornbeam area, it does not occur.

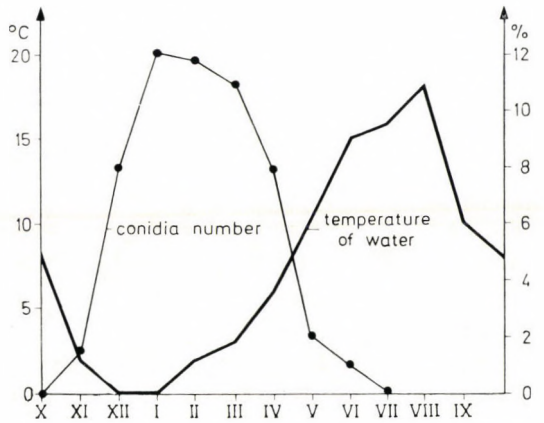


Fig. 16. Sporulation of *Clavatospora stellata* during the year as related to the total number of conidia (based on foam sample analysis)

The annual course of conidia production in the lower reaches displayed in 3 consecutive years (1969—1971), a regularity similar to that of *Clavatospora stellata*, but of a reverse trend. The increasing number of spores was correlated with increasing water temperatures (Fig. 17). During the winter months (November through April) of the three subsequent years the spores were extremely rare in the foam samples, then becoming gradually more frequent in May and June, it reached the late summer autumn maximum (August through October). In the instance of this species, sporulation cannot be related to leaf deposition during the autumn season since sporulation has reached its peak 2—3 months earlier. The assumption that ample conidia production was promoted by water temperatures about or above 10 °C, while it was retarded by much lower water temperature, seems well acceptable. This hypothesis is supported by the fact that the drop in water temperature in October through December was followed by a decrease in the number of conidia, even though the leaf substrate of the stream is the richest in this period. It is very probable that *Tetracladium marchalianum* is not one of the primary thallus colonizers, similarly to *Tricladium gracile*, but in opposition to the latter its conidia

production is not stimulated by low water temperatures. In the following years (1972—1973), a slight deviation in sporulation from earlier levels was evinced by *Tetracladium marchalianum*, if compared to earlier observations. In winter (beginning with November) conidia frequency did not reach the very low level observed during this period in previous years, and it did not reach the earlier observed frequency characteristic of the spring and the beginning of summer (April through July). Only samples taken in August and October displayed the frequency level corresponding to the average values found in

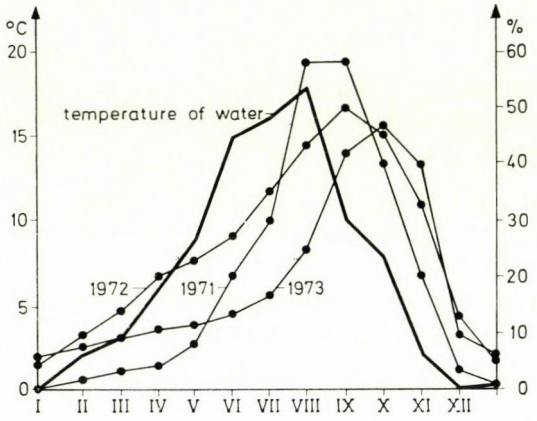


Fig. 17. Sporulation of *Tetracladium marchalianum* in relation to the total number of conidia in 1971—73 (based on foam sample analysis)

several years. The weather in both winters was also unusual. After a protracted and mild autumn only in mid January did a brief cold period set in and the water of the stream froze only for some days. Previous winters lasted longer, with repeated long cold periods.

Summary

The results of observations obtained hitherto can be grouped according to two viewpoints: distribution of the species in the stream system and seasonal occurrence. With regard to distribution, two well distinguishable alliances of species can be recognized, species which intermingle not or only to a small extent: one in the upper reaches, the others in the lower reaches. The former is the fungus group consisting of *Dactylella aquatica*, *Monotosporella tuberculata* and *Anguillospora crassa*, each distributed widely in the stream section of the beech area. The latter is the fungus group characterized by *Tetracladium marchalianum* and *Tricladium angulatum* of the lower reaches ranging in the stream section along the *Alnetum* stand.

While *Dactylella aquatica* and *Monotosporella tuberculata*, characteristic to the upper reaches grow according also to culture experiments on leaves peculiar to this region, *Tetracladium marchalianum* and *Tricladium angulatum*, characteristic to the lower reaches, do not grow in corresponding masses on leaves frequent in this section (*Alnus*, *Salix*, *Acer*, *Populus*), as it could have been expected on the basis on their conidia frequency in the foam samples.

The clear differentiation of the two species communities is — in my view — explainable in the distinct separation of the woody vegetation along the stream banks. Although I have only insufficient data from the investigation of other streams, the findings hitherto obtained indicate that in the case of streams where the species community of the accompanying vegetation differs from that of the Morgó Stream system, there the species community of aquatic Hyphomycetes is also different.

Further studies would be necessary to assess the linkage between the various fungus species and the various types of substrate and then to establish the extent of modification by environmental factors.

Observations concerning seasonal changes can be summarized as follows. Conidial production in this stream system and in some other streams is continuous during the year. This is understandable in the light of the fact that the aquatic Hyphomycetes have a substrate available during the whole year a substrate consisting of a thick accumulation of leaf litter especially in the deeper valley floors, which supplies the stream bed with leaf material continuously.

There is no doubt that the species composition of the fungal communities and the frequency of the species change seasonally. According to my observations, quantitative and qualitative changes in the species composition are not rapid but gradual and require a protacted period (1 to 2 months). Only some of the causes affecting these changes are known, and further studies are required to clarify the effects of the annual course of temperature, the condition of the substrate, and of the role of other ecological factors.

ACKNOWLEDGEMENTS

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NEW SCENEDESMUS SPECIES FROM THE DANUBE AT BUDAPEST

By

T. HORTOBÁGYI

(Received May 2, 1975)

Four new *Scenedesmus* species are reported from the collections made in the Budapest section of the river Danube in 1971—1972. The author dedicated the new species to Hungarian hydrobiologists (dr. Árpád BERCZIK, dr. István KISS, dr. Gábor SZEMES, dr. Gábor UHERKOVICH).

1. Scenedesmus Berczikii Hortob. n. sp.

Figs 1—2

Cells elongate cylindrical, outer walls of extreme cells slightly convex. Cells touching one another over 3/4 surface. Poles dome-like, convex. Membrane covered with small, but well discernible papillae. Poles covered with 1 or 2 latero-apically situated, cap-like, irregularly shaped, scabrous or smooth thickenings, occasionally extending over lateral sides as far as other pole, especially on extreme cells. Papillae on poles generally bigger. One parietal chloroplast including a well developed pyrenoid. Cap-like thickenings well discernible even on coenobia with plastids. Cell dimensions $10.5—13 \times 3—4.7\ \mu$.

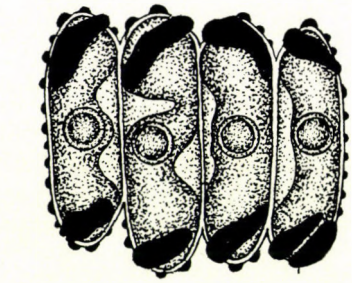
Danube, Sept. — Rare.

Cell shape similar to *Scenedesmus ecornis* (Ralfs) Chod. Its granulated membrane indicating relations with *S. granulatus* W. et W. The new species differs from both these species and subspecific taxa by its 1 or 2 large, shield-like, scabrous thickenings.

2. Scenedesmus Kissii Hortob. n. sp.

Figs 3—5

Coenobia with 4 or 8 cells, cells oval-ellipsoidal, touching one another over a small surface only, constituting loose coenobium. Cell dimensions $9—12 \times 5.6—8\ \mu$. Pole of each cell with one very thin, slightly arcuate, rarely straight, sharply pointed spine of equal length; length of spine $7—11\ \mu$. Intermediate cells sometimes with a spine. Cells including one well developed pyrenoid. Membrane not smooth.



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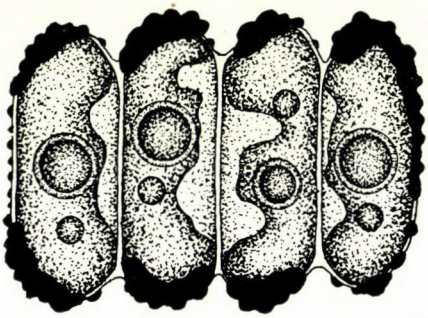

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Figs 1—2. Scenedesmus Berczikii Hortob. n. sp.

I have observed two abnormal coenobia. In one (Fig. 4) of them, two intermediary cells turned 90° from the plane of the extreme cells, and in one cell with only one spine developed. The other abnormal coenobium (Fig. 5) had only three cells closely adhering to each other, resulting in entirely smooth walls. On one of the poles not one but two spines developed.

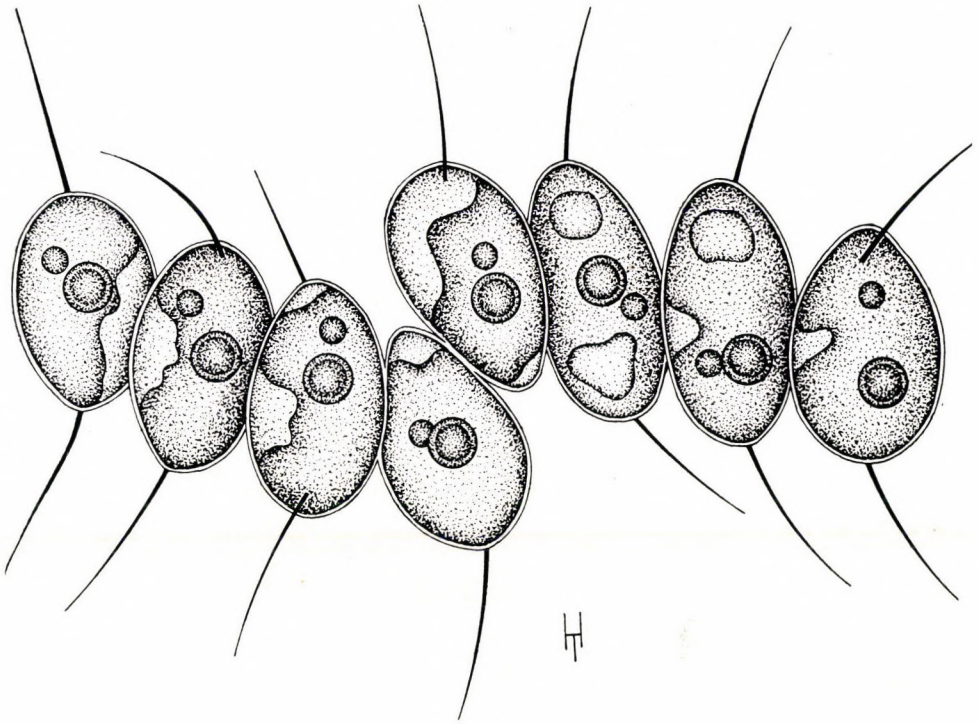
Danube, May. — Rare

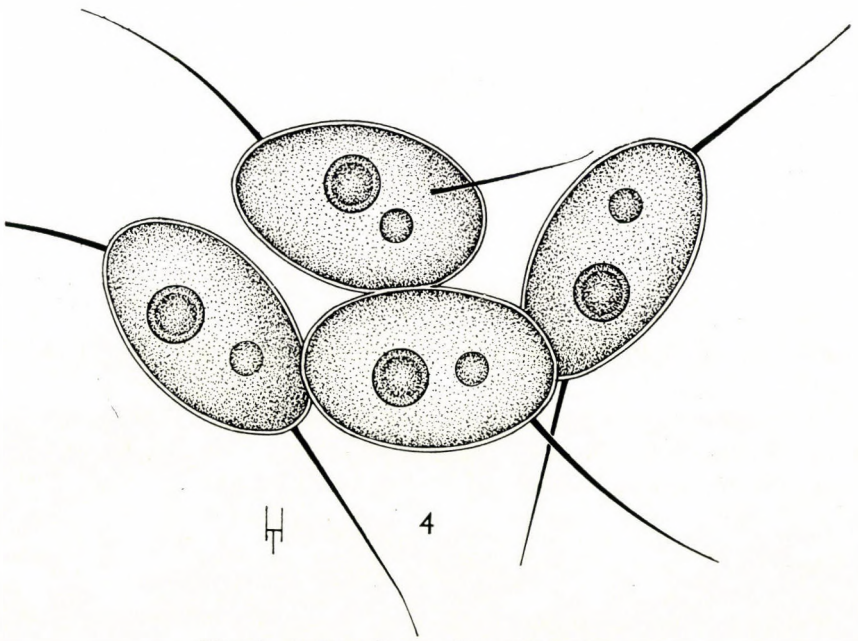
To this species belongs "*Scenedesmus quadricauda* (Turp.) Bréb. var. *biornata* Kiss" described by István Kiss in 1939 (Col. 237—238)). The cell dimensions of this species are $7.2-10.5 \times 3-4.5$ μ. Its extremely thick spines justify its separation as a form.

Owing to the cell shape and development of spines, the new species comes close to *S. ellipticus* (W. et W.) Chod. However, it differs from the latter by the different shape and the spines having developed on every pole.

3. Scenedesmus Kissii Hortob. f. **crassispinosus** (Kiss) Hortob. comb. n.

[(Scenedesmus quadricauda (Turp.) Bréb. var. biornata Kiss in Folia Cryptogamica 2/4. col. 237—238, Tab. XV, Figs 21, 26)].





Figs 3—4. Scenedesmus Kissii Hortob. n. sp.

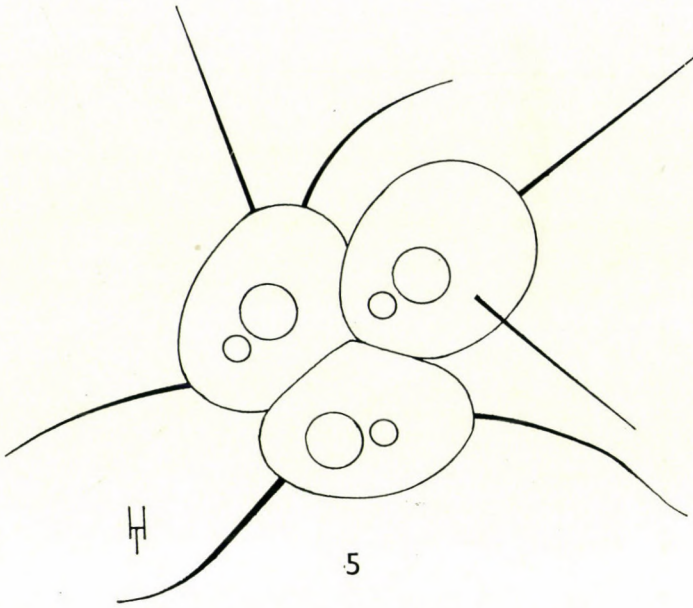


Fig. 5. *Scenedesmus Kissii* Hortob. n. sp.

Cell dimensions 7.2—10.5×3—4.5 μ. Spines as long as cell or somewhat longer, strikingly thick. Occasionally intermediary cells without spines. — Kisszék, June—July

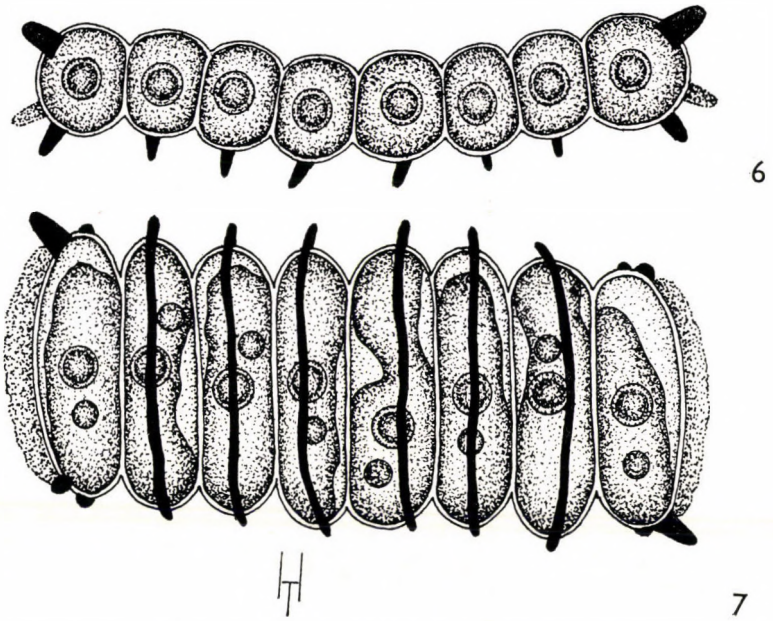
This form differs from the nominate species by its strikingly thick spines.

4. Scenedesmus Szemesii Hortob. n. sp.

Figs 6—7

Cells cylindrical, touching each other over their entire length. Outer walls of extreme cells convex. Cell dimensions 11.5—13×4.5—5.2 μ. Poles of extreme cells adorned with one very thick, short (1.8—2.2 μ) blunt pegs pointing outward; they have developed in one of the diagonals of the coenobium on the frontal part, therefore well discernible; in the other diagonal, at the back, these pegs are hardly perceptible, though they may be seen in a superior view. Beside them, one larger papilla is formed. Cells covered only on one side with a mucous, strongly elevated band. These are clearly perceptible in a frontal view on the extreme cells, while on the other cells they can best be viewed from above. Parietal chloroplast including one large pyrenoid.

Danube, August. — Very rare.



Figs 6—7. Scenedesmus Szemesii Hortob. n. sp.

The new species differs from all other *Scenedesmus* species by its short, squat, blunt projections and the thick mucous band decurrent only on one side of the cell.

5. Scenedesmus Uherkovichii Hortob. n. sp.

Fig. 8

Elongate, cylindrical cells, touching one another over their 3/4—4/5 surface. Poles domed. Cell dimensions 12.3—15×2.5—4 μ. Poles of extreme cells with one outward-pointing, arcuate-undulate, strikingly thick, blunt, 16—18 μ long spine each. Both extreme and intermediary cells with one row of papillae on longitudinal axis. Papillae locally coalescing. On the poles of intermediary cells mucous spines with wide bases and small spines, or denticles may be observed. Cells enveloped in 1—1.5 μ thick, grooved mucous sheath. Parietal chloroplast including one well developed pyrenoid.

Danube, August. — Rare.

The new species widely differs from all other *Scenedesmus* by its thick and arcuate, blunt extreme spines, the grooved mucous sheath, the row of papillae, the polar mucous spines and by the elongately shaped cells.

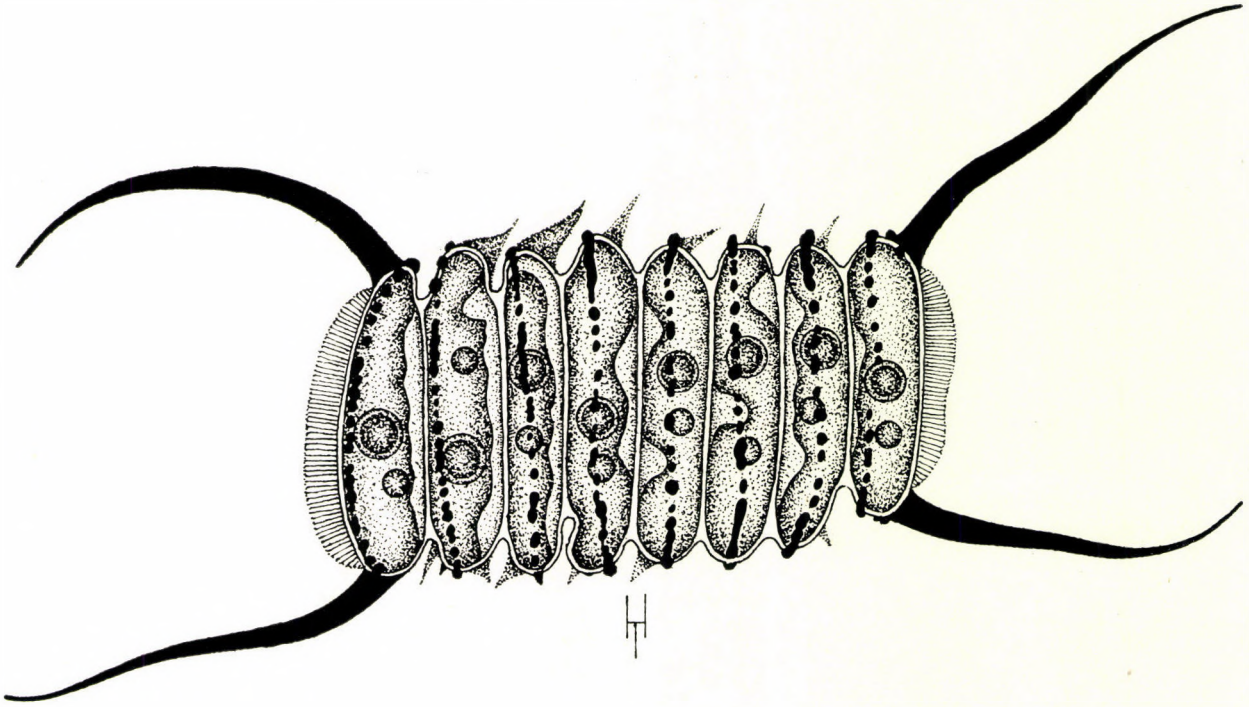


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Fig. 8. Scenedesmus Uherkovichii Hortob. n. sp.

DIAGNOSES

1. **Scenedesmus Berczikii** Hortob. n. sp.

Figs 1—2

Cellulae elongate cylindricae, sese cca. parte 3/4 superficiei lateralis attingentes, 10.5—13×3—4.7 μ, pariete extrorso cellularum extimarum forte parum convexo, polis semiglobose rotundatis, membrana granulis distinctis, circa polos majoribus, cooperta; polis 1 vel 2 incrassationibus, pileiformibus, magnis, obliquis, ad polos cellularum extimarum plerumque majoribus, nonnunquam fere polos vicinos attingentibus. Chloroplastis parietalis, cum pyrenoida unica, bene evoluta. Duna, IX. Raro.

Species haec nova forma cellularum et coenobiorum *Scenedesmum ecornem* (Ralfs) Chod. in mentem revocat. Membrana granulata eius propinquitatem cum *Scenedesmo granulato* W. et W. indicat. A specibus supradictis et taxonibus eorum minoribus incrassationibus 1 vel 2 ad polos dispositis, magnis, bene evolutis, scutelliformibus, verrucosis bene distinctus.

2. **Scenedesmus Kissii** Hortob. n. sp.

Figs 3—5

Cellulae ovales, ellipsoides, superficie parva sese attingentes, 9—12×5.6—8 μ, membrana non levi, coenobia laxa formantes; in polis omnibus spinis singulis, longitudine aequalibus, tenuissimis, parum arcuatis, raro rectis, 7—11 μ longis, acutatis ornatae, Chloroplastis parietalis, pyrenoida bene evoluta. Duna, V. — Raro.

Propter formam cellularum et partim spinarum Scenedesmus ellipticus (W. et W.) Chod. ei proximus. Ab eo forma cellularum et spinis longis gracilibus, in omnibus polis dispositis distinctus.

3. **Scenedesmus Kissii** Hortob. f. **crassispinosus** (Kiss) Hortob. comb. n.

Magnitudo cellularum 7.2—10.5×3—4.5 μ. Spinae polorum sunt magnitudinis cellulae, aut paulisper longiores, conspicue crassae. Nonnunquam cellulae intermediae non habent spinas. — Kisszék, VI—VII. — Fig.: Folia Cryptogamica 2/4. Tab. XV. Figs 21, 26.

Cum specie discrepat suis spinis, conspicue crassis.

4. **Scenedesmus Szemesii** Hortob. n. sp.

Figs 6—7

Cellulae cylindricae, maxima parte longitudinis sese attingentes, 11.5—13×4.5—5.2 μ; cellulae extimae lateribus extrorsis convexis, in polis appendicibus singularibus crassis, trunciformibus, 1.8—2.2 μ longis, extrorsis, apice late rotundatis, superne visu omnibus simul observabilibus, a latere secundum unum diagonalem tantum dispositis, secundum alterum pariter haud conspicuis, praeter eas granulis singulis majoribus ornatae. Cellulae mediae omnes in uno latere coenobii, cellulae autem extimae in latere extrorso cristis longitudinalibus, singulis mucilagineis, satis crassis, valde altis, in cellulis extimis etiam e latere, in cellulis ceteris superne visu conspicuis. Chloroplastis parietalis, in eo pyrenoida unica bene evoluta.

Duna, VIII. Rarissime.

Species nostra appendicibus cellularum extimarum brevibus, crassis, trunciformibus et cellulis cristis singularibus, longitudinalibus, in uno latere tantum dispositis, mucilagineis, valde emergentibus ab omnibus taxonibus generis *Scenedesmus* bene distincta.

5. **Scenedesmus Uherkovichii** Hortob. n. sp.

Fig. 8

Cellulae elongate cylindricae, parte 3/4—4/5 longitudinis sese attingentes, 12.3—15×2.5—4 μ, polis valde rotundatis; cellulae omnes indumento 1—1.5 μ crasso, mucilagineo, fibrilloso in cellulis extimis a latere etiam conspicuo coopertae, deinde seriebus singulis longi-

tudinalibus, medianis granulorum in nonnullis locis conniventibus instructae. Cellulae coenobiorum extimae polis spinis singulis, extrorsis, inclinatis-undulatis, eximie crassis, obtusis, 16—18 μ longis armatae. Cellulae mediae polis spinis-denticulis mucilagineis, ad basin dilatatis ornatae. Chloroplastis parietalis, pyrenoida bene evoluta.

Duna, VIII. Raro.

Species nostra spinis crassis, inclinatis, obtusis, extimis, indumento mucilagineo, fibrilloso, deinde seriebus granulorum longitudinalibus, spinis mucilagineis polorum atque cellulis elongatis ab omnibus taxonibus descriptis generis *Scenedesmus* bene distincta.

*

Species novae superius descriptae in honorem hydrobiologorum egregiorum Hungariae: dr. Árpád Berczik, dr. István Kiss, dr. Gábor Szemes et dr. Gábor Uherkovich nominatae sunt.

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THE INFLUENCE OF MONOCHROMATIC BLUE AND RED LIGHT ON THE ELECTRON MICROSCOPE STRUCTURE OF CHLOROPLASTS

By

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Pepper plants cultivated in near-monochromatic blue and red lights generally exhibit parallel growth between the extent of granulosity of chloroplasts, the number of grana-vesicles and the increment of wavelength. The photosynthetic production is primarily dependent on granularity.

Introduction

The electron microscope structure of the chloroplast is significantly affected by light. Best known is the effect which light intensity exerts on the development of grana and stroma thylakoids (PRIOUL, 1973; BRANGEON, 1973). Depicted, the character of this effect yields an optimum curve which, however, is subject to modification depending on whether it is an expression of shade or light ecoplants or it reflects the number of chloroplasts present in the various tissue cells.

Next to structural differences, light intensity influences the quantity of photosynthetic pigment system as well as its quality. It is widely recognized that lower light intensity increases the quantity of chlorophyll b while it reduces the carotenoid content (GRAHL, 1972).

Temperature, besides light intensity, also greatly influences granum development. In the instance of soybean a greater number and size larger grana develop at high temperature and in lower light intensity (BALLATINE and FORDE, 1970). Of the modes of light effects, less well-known is the role quality plays on the chloroplast structure, since content analysis can only be undertaken in near-monochromatic light. The study of this effect is important because, as described in our earlier paper (HORVÁTH and SZALAY, 1974), energy migration induced by this wavelength influences photosynthetic production, as assays conducted in near-monochromatic light demonstrate.

Materials and methods

Near-monochromatic light was produced by Zeiss manufactured metal interference filters.

Considering the absorption spectrum of chlorophyll a and b, the following interference filters with maximum transmission were utilized: 425, 450, 475, 650 and 675 nm. Two pigment components absorbed energy in widely varying ratios from the light transmitted by these filters.

For light source a halogen lamp of 1 kW was used and infrared rays were filtered through a 10 cm thick running water layer. For control, plants were grown under this lamp. Light energy was the same under the filters and at the control points: $7.2 \cdot 10^{-3}$ cal cm^{-2} min^{-1}. Illuminance was rendered for 12 hrs during the day, night time temperature was ab. 20°C and 28 °C in the day time.

White peppers from the region of Keszthely were used as assay plants. The filters were placed on double-walled culture boxes where the plants grew in sand. The alternate walls of the culture boxes were perforated. Aeration was thus ensured and light penetrated the inner space of the box only through the interference filters. (The walls of each box facing each other were of black colour.)

The plants were examined when they were 14 days old. (Owing to the small-sized interference filters, the plants could not be grown for a longer period.) Pigment content of the seminal leaf was determined (HORVÁTH and SZALAY, 1974), its tissue structure examined by light microscope and the structure of the chloroplasts by electron microscope.

For the electron microscopic analysis small pieces were taken from 5 seminal leaves and fixed in 3% glutaraldehyde. After 3 hrs of fixation the segments of tissue were washed in phosphate buffer and postfixed in 2% $KMnO_4$. In the ethanol dehydrated material was embedded in durcupan ACM.

Ultrathin sections were stained with uranyl acetate and lead cytrate and examined with 100B type JEM electron microscope.

With respect to the electron microscope structure of the chloroplast, primary stress was laid on ratio determination between the grana and stroma as well as the number of vesicles building the grana.

Results and discussion

The grana ratio was established on the basis of the cross section by calculating the grana-occupied area for the entire cross section in percentage. This is of course a relative number but it reflects well the granularity of the plastids.

Plants grown at wavelengths of 450 and 475 nm had chloroplasts of weak grana structure and the grana vesicles number generally lay between 2—5 (Plates I and II). Plastids of plants raised in light of 425 nm wavelength contained 2—6 prolamellar bodies, whereas they were lacking from other samples subjected to the identical assay conditions.

Plastids of plants raised in light of 650 and 675 nm revealed better developed grana and the number of vesicles lay significantly higher, between 6 and 12 (Plates II and III).

According to the line of progress, the following numerical results were obtained (Table 1):

Table 1

Wavelength	Participation ratio of grana in %	Dry weight of a single plant in mg
450 nm	11.6	5.2
475 nm	17.5	5.5
675 nm	23.3	6.5
425 nm	23.9	7.0
650 nm	38.3	8.1

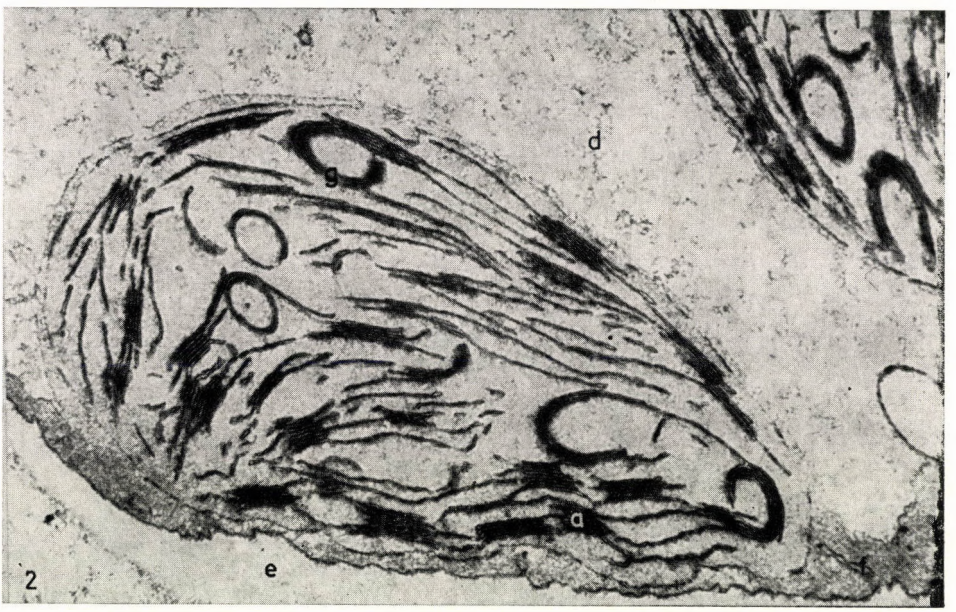

Plate I. 1: Plastids of plants raised in light of 425 nm wavelength (magnification 20 000). *2:* 450 nm (magnification 20 000). Explanation: a = grana, b = prolamellar body, c = mitochondria, d = cytoplasm, e = cell wall, f = endoplasmatic reticulum, g = deformed grana

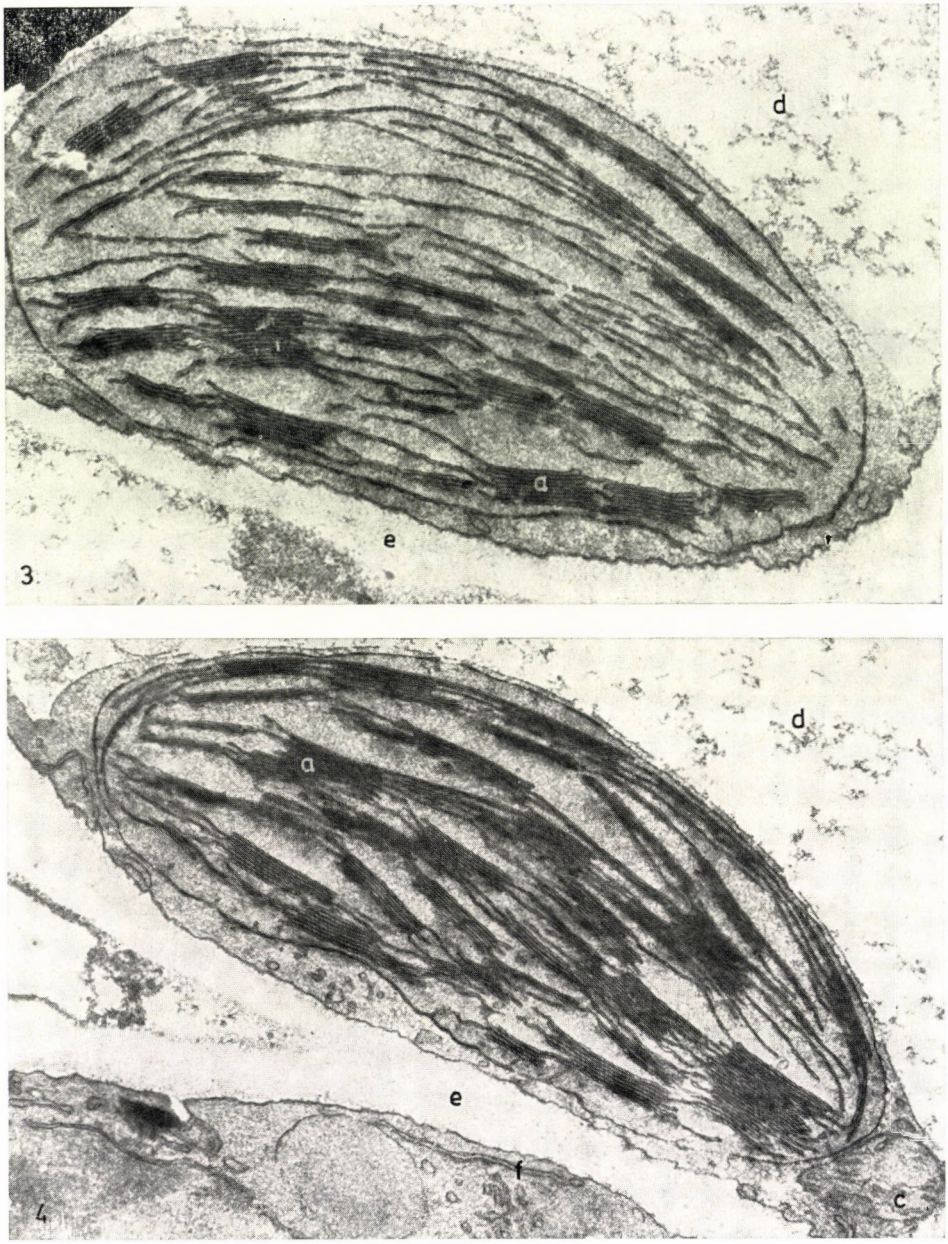

Plate II. 3: Plastids of plants raised in light of 475 nm wavelength (magnification 20 000).
4: 650 nm (magnification 20 000)

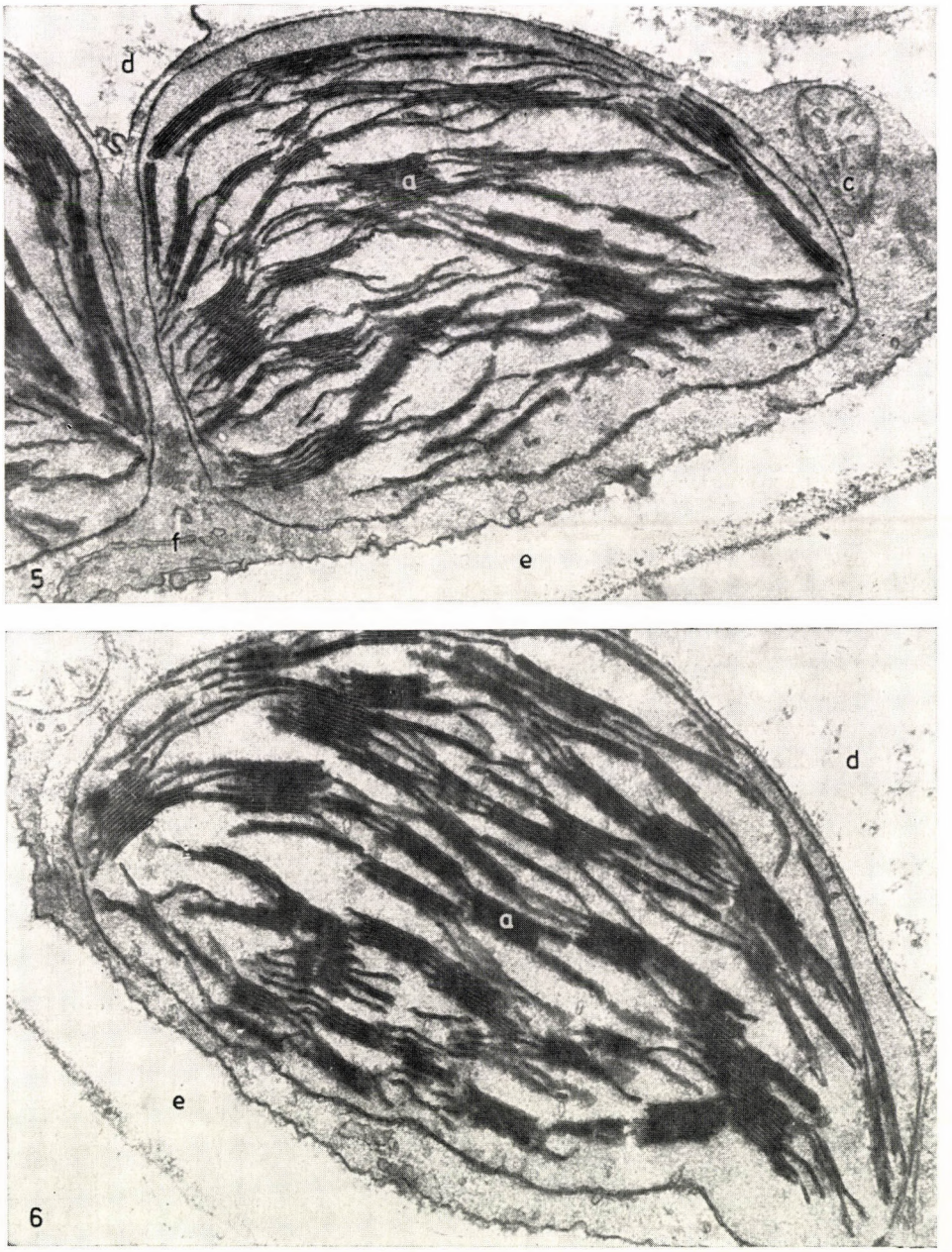

Plate III. 5: Plastids of plants raised in light of 675 nm wavelength (magnification 20 000)
6: control (magnification 20 000)

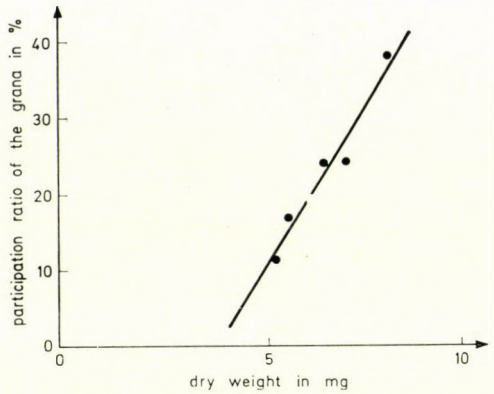

Fig. 1. Relationship between the participation ratio of the grana and the dry weight of plants

It can be ascertained that the granularity of chloroplasts and the dry weight of plants, respectively, are in close relationship which is nearly linear between them (Fig. 1).

The results indicate that the numerical increase of the vesicles brings about an accelerated photosynthetic activity. Next to the number of vesicles, the grana ratio is the most important; it even seems that this ratio is the primary factor which stimulates photosynthetic activity. The plants grown under the filters of 425 and 675 nm exhibited great numerical difference concerning their grana vesicles, whereas the participation ratio of the grana and also of the dry weight is almost of corresponding value.

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CRYOBIOLOGICAL RESEARCHES IN THE HIGH TATRA II.

By

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The first part of the study was published in the Acta Bot. Hung., 1975, 21: 1—2. The present part summarizes the known microorganisms of the snow surfaces in the High Tatra, their conditions of occurrence and the various cryobiotopes. The snow vegetation of the High Tatra is highly diverse, microorganisms inhabiting removed regions occur also here. Owing to its central position, the High Tatra is an aerobiologically important centre, harbouring not only cryobionts of the Northern Hemisphere, but also some of the Southern Hemisphere. The third period of cryobiological investigations in the High Tatra is also discussed.

The snow microorganisms of the High Tatra and their geographical distribution

In Table 3, data related to the conditions of occurrence of microorganisms found so far on the snow spots and the snow fields of the High Tatra are given according to locality, altitude, author, pH, colour of snow, frequency, cryobiological character and distribution.

It appears from the Table that a total of 67 microorganisms have so far been known from the snow surfaces of the High Tatra, partly from literature, and partly from the investigations of KOL.

Among the 67 species, there are 2 *Chrysophyta*, 35 *Chlorophyta*, 22 *Cyanophyta*, 5 *Fungi* and *Bacteriophyta*, — 34 of the species are cryobionts, 9 species are cryophilous and 24 species are of a cryoxenous character.

Among the species of a cryoxenous character, *cyanophytes* predominate; these arrive to the snow-surface probably from the neighbouring rock walls. Among the cryobionts, the chlorophytes are the preponderant ones.

There are algae which propagate in certain areas so much abundantly that they cause cryoseston colourations. Such is *Chlamydomonas nivalis* causing red snow (Bau./Wille; Pl. I, Figs 4—6), one of the most wide-spread cryobionts is *Chlamydomonas sanguinea* Lag. (Part. I., Pl. I, Figs 42—47). *Scotiella tatrae* Kol (Part I., Pl. I, Figs 30, 36), causing pink snow in the Tatra Mountains,

has so far been known only from that region. *Chlamydomonas flavovirens* Rostaf. and *Chlamydomonas rostafinskii* Starmach et Kavecka (Part I., Pl. I, Figs 51—54) cause yellow seston discolouration. The yellow and red snow blooms are characteristic seston colours in the snow of the Granite Tatra. *Chromulina ettlii* Hindák causes yellowish-brown snow colourations.

A characteristic coloured snow of the limestone region, of the Bela Limestone Alps, is the green snow caused by *Koliella tatrae* (Kol/Hindák; Pl. I, Figs 23—29) and by *Carteria gyoerffyi* Kol (Pl. I, Figs 1—9).

Black snow characteristically occurs in the snow of the Tatra Mountains. It is caused partly by carbonization, partly by *Chlorobacteria* and other bacterium species.

A number of algal species live exclusively in the Tatra Mountains, for example *Carteria gyoerffyi* Kol (Pl. I, Figs 1—8), *Chlamydomonas rostafinskii* Starmach et Kavecka (Pl. I, Figs 51—54), *Chlamydomonas flavovirens* Rostaf. *Ankistrodesmus longissimus* var. *rostafinskii* Kol, *Scotiella tatrae* Kol (Pl. I, Figs 31—33), *Cosmarium subspeciosum* var. *schaarschmidtii* Kol, *Cryptomonas frigoris* Hindák, *Chromulina ettlii* Hindák. For the time being, these can be considered as endemic plants of the High Tatra.

The High Tatra, having a central position in Europe, harbours a number of algae which occur on the snow fields of Europe, North America and also other distant regions, for example *Chlamydomonas nivalis*, *Trochiscia cryophyla*, *Troch. nivalis*, *Tetraedron valdezii*, *Raphidonema nivale*, *Chlamydomonas sanguinea*, *Scotiella cryophila*, *Koliella tatrae*. *Chionaster bicornis* Kol, one of the characteristic snow fungi of North America and even of Alaska, occurs also in the Tátra.

Nivicolous algae, so far known only from the snow surfaces of the Carpathians can also be found in the Tatra, e.g. *Carteria gyoerffyi* Kol, *Raphidonema tatrae* var. *fogarasiensis* Kol, and others. On the other hand, there are also some species endemic almost only in the Northern Hemisphere: *Chionaster nivalis* (Bohl.) Wille, *Ch. bicornis* and other.

Bipolar microorganisms also live in the Tatra; they have been found so far on the snow surfaces of the Northern and Southern Hemispheres. Such are *Raphidonema nivale* Lagerh., *Scotiella nivalis* (Chod.) Fritsch, *Selenotila nivalis* Lagerh., *Trochiscia nivalis* Lagerh., *Chlamydomonas sanguinea*, *Mesotaenium berggrenii* (see Table 3).

As far as aerobiology is concerned, this variety in the snow vegetation of the Tatra and the differing origins of the members of the snow algal association as well as their distribution in different directions can be explained by the central position of the Tatra.

A number of species is also found among the snow algae of the Tatra which are endemic in the mountains lying near to it, namely in the Carpathians, or in the Balkan Mountains.

Recent cryobiological researches in the Tatra; the third period of cryobiological researches

The third period which can also be called the modern age of cryobiological researches began with the examination of the physical and chemical characteristics of habitats. The determination of the pH value of snow in the High Tatra was begun by KOL in 1932 (see the Chapter on pH measurements). She carried out pH and temperature measurements of ice and snow in the Alps in 1933, and at various points of the Rocky Mountains in North America in 1936. She classifies the cryobiotopes on the basis of these pH measurements (see KOL 1968. 26).

Measurements of the pH values of cryobiotopes were continued in various parts of the world: H. FUKUSHIMA in Japan (1953), and in the Antarctica (1959); R. K. GARRIE in North America: Olympic Nat. Park, Mt. Rainier Nat. Park, and in other mountains (1965); W. H. THOMAS in the Sierra Nevada, California (1969); G. E. FOGG in the snow fields of the Antarctica (1959); S. EUROLA in Finland and in the Spitzbergen (KOL—EUROLA 1973); J. P. PETERSON in the Carstens Mountains of New Guinea (1973).

In 1833, CHORUS carried out light measurements in connection with cryobiological researches in the Jungfrau Pass (KOL 1968); others have also conducted pH and other measurements in connection with quantitative snow vegetation examinations since that time: G. B. FOGG (1970) in the Antarctica; W. H. THOMAS in the Sierra Nevada, California (1969); S. EUROLA in Finland and in the Spitzbergen (KOL—EUROLA 1973); J. P. PETERSON in the Carstens Mountains of New Guinea.

As regards the cultivation of snow microorganisms, and obtaining the pure species cultures A. E. FLINT was the first to succeed in cultivating some algal cryobionts, on one of the island groups of the Antarctica, from the green snow collected on the Balley Islands (KOL—FLINT 1967). G. E. FOGG carried out cryobiological, physiological quantitative researches and set up cultivations in the Orkneys. STEIN and BROOKE (1964) cultivated *Sphaerellopsis rubra* Stein et Brooke, an alga from the snow surfaces of the Seymour Nat. Park in British Columbia; J. STEIN (1963) cultivated *Chromulina chionophila* Stein from the snow of British Columbia.

It is a welcome phenomenon that cryobiological researches today have taken a greater impetus in the High Tatra. W. H. THOMAS (1970) carried out various measurements, researches, quantitative analyses, and set up cryoalga cultivations in the Sierra Nevada, California.

Physiological, coenological, cryophysiological researches and cryoalga cultivations have begun.

In the High Tatra, HINDÁK succeeded in cultivating pure strains of one characteristic alga of the green snow in the Bela Limestone Alps, namely

Table 3

The distribution of the microorganism

Microorganisms	Locality	Author
A l g a e		
Chrysophyta		
Chromulina ettlii Hindák	12	H
Cryptomonas frigoris Jav. et Hindák	31	J—H
Chlorophyta		
V o l v o c a l e s		
Carteria gyoerffyi Kol	5	K_4, P, K
Carteria nivalis var. *minor* Kol	11	K_7
Chlamydomonas flavovirens Rostaf.	24, 27	Be, P, Ps, R
Chlamydomonas nivalis (Bau.) Wille	1—4, 7—11, 12—23, 24—27, 29	K, K_1, K_5, K_{6-9}, J, M, P, R, S
Chlamydomonas rostafinskii Starmach et Kavecka	2, 25	J, H, St
Chlamydomonas sanguinea Lagerh.	12, 21	K_8, K_9
Fortiella scrobiculata Pascher	1, 2, 3, 4	K_1, K_5
Haematococcus lacustris (Girad) Rostaf. = *Chlamydomonas nivalis* (Bau.) Wille.	2, 27	P, R
Pteromonas nivalis Chod. = *Scotiella nivalis* (Chod.) Fritsch	2, 3	K_1, Sch
P r o t o c o c c a l e s		
Ankistrodesmus longissimus (Lemm.) Wille var. *rostafinskii* Kol.	1, 11	K_1, K_3, K_7
Ankistrodesmus tatrae Kol = *Raphidonema tatrae* Kol = *Koliella tatrae* (Kol, Győrffy) Hindák	1, 5	K_1, K_4, H
Scenedesmus cf. *bijugatus* (Turpin) Kg.	25	St
Oocystis gigas var. *borgei* Lemm. f. *nivicola* Kol	12, 3a	K
Pleurococcus vulgaris var. *cochaerens* Wittr.	5, 7, 13, 14, 15, 3a	K, K_9, Sch
Scotiella cryophila Chod. = *Pteromonas cryophila* Chod.	2, 26	Ps, K
Scotiella nivalis (Chod.) Fritsch = *Pteromonas nivalis* Chod	2, 3, 3a, 7, 11, 14, 20, 22, 23, 29	K, K_1, K_5, K_7, P, Si
Scotiella tatrae Kol	10	K_7
Tetraedron valdezii Kol	3a, 5, 7, 12—16, 19	K, K_8
Trochiscia nivalis Lagerh.	22	Si
Trochiscia cryophyla Chod.	13	K
Scotiella norvegica Kol f. *minor* Kol	13	K_9
U l o t r i c h a l e s		
Gyoerffyella tatrica Kol = *Gyoerfyella tatrae* Kol = *Gyoerffyella rotula* (Hőhni) Marv.	1, 2, 11	K_1, K_5, K_7, P
Hormidiopsis crenulata (Kg.) Heering	11	K_7
Koliella tatrae (Kol in Győrffy) Hindák	11, 12, 14	K, K_7, K_8, K_9
Koliella tatrae var. *fogarasensis* (Kol) Hindák	11	K_7
Raphidonema brevirostre Scherffel	2, 3, 3a, 12, 14	K, K_1, K_5, K_8
Raphidonema nivale Lagerh.	1, 3, 3a, 6, 7, 12, 13, 15, 17—20	K, K_1, K_5, K_8
Raphidonema sabaudum f. *tatrica* Kol	11, 12	K_7, K_8
Raphidonema longissimus var. *rostafinskii* Kol = *Ankistrodesmus longissimus* var. *rostafinskii*. Kol	1	K_2, K_5
Stichococcus nivalis Chod.	11, 12, 13	K, K_7, K_8
Ulothrix flaccida Kg.	1	K_1, K_5

in the snow of the High Tatra

Character of the snow			Occurrence		Type of the micro-org.	Distribution		
Altitude	pH	Colour	Granite	Lime-stone				
1600	5.1	y—br	ra	—	cb	ra	ra	—
2000	—	g, r	—	—	cb	ra	—	—
1700—1800	6.5—6.0	g	—	c	cb	ra	—	—
1500	—	b	—	—	cb	ra	—	—
1880	—	y	—	—	cb			
1680, 2000, 2180	5.5—5.4	r, b	—	—	cb	c	c	c
2000	—	y	ra	—	cb	ra	—	—
1950	5.5	r	ra	—	cb	ra	ra	—
1340, 2180	5.5—6.0	—	ra	—	cx	ra	—	—
—	—	r	c	—	cb	c	c	c
1680, 2150	5.5	r, b	—	—	cb	c	c	—
1340, 1800	5.5	b	r	ra	cb	ra	—	—
1340, 1500	6.5—6.0	g	ra	c	cb	c	ra	ra
—	—	y	ra	—	cb	ra	—	—
1700	5.5	b	ra	—	cp	ra	—	—
1700, 1950	5.5	b	c	ra	cp	c	c	ra
2180	5.5—5.4	r	ra	—	cb	ra	ra	ra
1340, 2180	6.5—5.4	r, g, b, p	c	ra	cb	c	c	c
2000	5.5—4.4	r, p	ra	—	cb	ra	—	—
1800, 2700	5.5	g	ra	—	cb	ra	ra	ra
2000	—	—	ra	—	cb	ra	ra	ra
—	—	b	ra	—	cb	ra	ra	ra
1950	5.5	b	ra	—	cb	ra	ra	—
1340, 2180	6.5—5.5	r, g	ra	ra	cp	ra	—	—
1500	—	—	ra	—	cx	ra	—	—
1340, 1500	6.5—5.5	g	ra	c	cb	c	ra	ra
1500	—	—	ra	—	cb	ra	ra	—
1710, 2180	5.5	r	ra	—	cb	ra	ra	—
1340, 1680, 1710, 2250	6.5—5.4	r, g	c	ra	cb	c	c	c
1500	—	—	ra	—	cb	ra	—	—
1340	6.5—6.0	g	—	ra	cb	ra	—	—
1500	5.5	b	ra	—	cb	ra	—	—
1340	6.5—6.0	g	—	ra	cx	ra	—	—

Table 3 (cont.)

Microorganisms	Locality	Author
Conjugales		
Desmidiaceae		
Ancylonema nordenskiöldii Berggr.	25	St
Cosmarium subspeciosum Nordst. var. *scharschmidtianum* Kol	2	K_1
Cylindrocystis brebissonii var. *minor* West. et West.	11, 12	K_7, K_8
Mesotaenium berggrenii (Wittr.) Lagerh.	16	K
Mesotaenium macrococcum var. *micrococcum* (Kg.) G. et W. West.	11, 12	K_7, K_8
Cyanophyta		
Aphanocapsa nivalis Lagerh.	1	K_1, K_5
Chalothrix parietina (Neeg.) Thur.	11	K_7
Chroococcus rufescens (Bréb.) Näg.	2	K, K_5
Chroococcus scherffelianus Kol	2	K, K_5
Gloeocapsa alpina Näg.	1, 3a, 15, 19, 28	K, K_1, K_5, K_8, R
Gloeocapsa kuetzingianum Näg.	1, 12, 3a	K, K_1, K_5, K_8
Gloeocapsa magna (Bréb.) Kg.	3a	K
Gloeocapsa muralis Vig.	3a	K
Gloeocapsa ralfsii (Harv.) Lemm.	1, 2, 3, 7, 11, 12, 15, 16, 19, 20, 3a	K, K_1, K_5, K_7, K_8
Gloeocapsa ralfsiana (Harv.) Kg. = *Gloeocapsa ralfsii* (Harv.) Lemm.	22, 28	Si, R
Gloeocapsa sanguinea (Ag.) Kg.	2, 3a, 13, 19	K, K_1, K_5
Gloeocapsa turgida (Kg.) Hollerbach	25	St
Gloeothece fuscolutea Näg.	3a	K
Nostoc fuscescens Fritsch	2	
Petalonema densum (A. Br.) Mig.	2	K_1, K_5
Phormidium frigidum Fritsch	1	K_1
Romeria cryophyla Kol	11, 13	K_7, K_8
Siphononema polonicum (Rac.) Geitler status *pleurocapsoides*	11	K_7
Stigonema hormoides (Lagerh.) Ag.	3a	K
Stigonema mamillosum (Lyngb.) Ag.	12, 3a	K, K_8
Scytonema minor (Schmidle) Lemm.	1	K_1, K_5
Scytonema minor var. *istvanffiana* Kol	4	K_1, K_5
Fungi		
Asterothrix raphidioides (Reinsch) Printz	11	K_7
Chionaster bicornis Kol	3a, 10, 11, 15, 16, 19, 20, 22	K, K_6, K_7, Si
Chionaster nivalis (Bohl.) Wille	1, 3, 4, 8, 9, 10—20, 22, 29, 3a	K, K_1, K_5, K_7, Si, Sch
Gyoerffyella rotula (Hőhn.) Marvanová = *Gyoerffyella tatrica* Kol	30	M
Selenotila nivalis Lagerh.	1, 16	K, K_1
Bacteria		
Sorochloris aggregata var. *nivicola* Kol	12	K_8
Chlorobacteria sp.	11, 12, 14, 3a	K, K_7, K_8

Abbreviations in Table 3 see p. 287.

Character of the snow			Occurrence		Type of the micro-org.	Distribution		
Altitude	pH	Colour	Granite	Lime-stone				
—	—	y	r, ra	—	cb	r, ra	c	c
2180	5.5	r	ra	—	cp	r	—	—
1500	5.5	b	ra	—	cp	ra	—	—
—	—	b	ra	—	cb	ra	c	c
1340—1680	5.5	b	ra	—	cx	ra	—	—
1340	6.5—6.0	g	—	ra	cp	ra	ra	—
1500	—	—	ra	—	cx	—	—	—
2180	5.5	r	ra	—	cx	—	—	—
2180	5.5	r	ra	—	cp	—	—	—
1340—1710	5.0—5.5	g, b	c	c	cb	ra	ra	—
1340—1710	5.5	b	ra	—	cx	ra	—	—
1700	5.5	b	ra	—	cx	ra	—	—
1710	5.5	b	ra	—	cx	—	—	—
1340—1710	6.5—5.5	r, b, g	c	ra	cp	c	c	c
—	—	r	ra	—	cx	—	—	—
1700—2180	5.5—5.4	r	c	ra	cx	c	ra	ra
—	—	y	ra	r	cx	ra	—	—
2180	5.5	b	ra	—	cx	—	—	—
2000	5.5	r	ra	—	cx	—	—	—
2180	5.5	r	ra	—	cx	—	—	—
1340	6.5	g	ra	ra	cx	—	—	—
1500—1950	—	b	ra	—	cx	—	—	—
1500	—	—	ra	—	cx	—	—	—
1700	5.5	b	ra	—	cx	—	—	—
1700	5.5	b	ra	—	cx	—	—	—
1340	6.5	g	ra	—	cx	—	—	—
2047	—	—	ra	—	cx	—	—	—
1500	—	—	ra	—	cx			
1340—2280	5.5	r, p	ra	—	cb	ra	ra	ra
1340—2180	6.6—5.5	g, b	c	c	cb	c	ra	ra
1800	—	—	ra	—	cx	ra	—	—
1340—1700	6.0—5.5	g, b	ra	ra	cb	ra	ra	ra
1700	5.5	b	ra	—	cp	ra	—	—
1500—1710	5.5	b	ra	ra	cb	ra	ra	ra

Koliella tatrae (Kol) Hindák. Then JAVORNICKY and HINDÁK cultivated *Chromulina ettlii* Hindák, causing the yellowish-brown cryoseston colourations in the Tatra. They also succeeded in pure cultivations of *Cryptomonas frigoris* Javornicky—Hindák, a chrysophyte. They carried out cryoecological, physiological, optical and other researches; and KOMAREK, HINDÁK and JAVORNICKY, at various points of the High Tatra: 1. in the Valley Pod Sikou; 2. in the Valley of Zmszla Velki Znrzla; 3. in the Valley Malá Stidená Dolina; 4. in the Valley Tristárská Dolina (KOMAREK—HINDÁK—JAVORNICKY 1973).

Summary

The paper mentions 67 microorganisms from the snow surfaces of the High Tatra; among them, 34 are cryobionts, 9 of cryophilous and 24 of cryoxenous character (see Table 3). The microorganisms of two kinds of red, one pink and one yellowish-brown, two kinds of yellow, and two kinds of green cryosestone colourations are known. It can be stated that the cryovegetation of the High Tatra is rich in species. From an aerobiological point of view, the High Tatra is significant, its location is central, and this is how the rather far-reaching geographical distribution of snow alga species of the Tatra Mountains is explainable.

On the basis of KOL's pH measurements, the pH value of the snow fields in the Granite Tatra is between 5.5 and 5.2, and these pH values are characteristic of the red and pink snow colours. The pH value of the snow surfaces in the Limestone Tatra, the Bela Limestone Alps lies between 6.5 and 6.0, these pH values are characteristic of the green cryoseston (see Table 2).

In the course of cryobiological researches, three periods can be distinguished: 1. the observation of coloured snows; 2. morphological, taxonomical and cytological researches of the algae causing coloured snows, and in general of the microorganisms living on snow and ice surfaces; 3. investigations of the physical and chemical characteristics of cryobiotopes; quantitative, physiological, ecological, and optical examinations; cultivation of cryo-microorganisms and the setting up of pure cultivations.

Cryobiological researches in the High Tatra area belong in the third period. KOL took pH measurements (see Tables 1 and 2), KOMAREK, HINDÁK and JAVORNICKY conducted cryo-ecological, physiological, and optical researches into snow colourations; and they set up cultivations of the new species *Cryptomonas frigoris* Hindák—Javornicky and *Chromulina ettlii* Hindák; the latter from the yellow and yellowish-brown cryoseston of the Tatra Mountains. HINDÁK also succeeded to obtain a pure cultivation of *Koliella tatrae*, causing the green snow in the Tatra.

The authoress summarizes in Table 3 the microorganisms of the vegetation known so far in the Tatra. The Table reveals that a number of bipolar,

alpine, alpine-arctic microorganisms live in the snow of the Tatra. According to KOL's classification, the cryovegetation of the Tatra belongs in the third upper cryovegetation type (KOL 1968). Some endemic snow alga species also belong here, together with species which live also in the snow fields of North America, Alaska, and even in the Antarctica.

Abbreviations in Table 3*

1—31 = Locality of collections (snow samples); G = GUTWINSKI 1909, GY_1 = GYŐRFFY 1927a, GY_2 = GYŐRFFY 1927b, GY_3 = GYŐRFFY 1928, H = HINDÁK 1963, H_1 = HINDÁK 1969, J—H = JAVORNICKY et HINDÁK 1970, K = KOL in mscr, K_1 = KOL 1928, K_2 = KOL 1927, K_3 = KOL 1927a, K_4 = KOL 1949, K_5 = KOL 1948, K_6 = KOL 1965, K_7 = KOL 1966, K_8 = KOL 1967, K_9 = KOL 1968, K_{10} = 1969, M = MARVANOVÁ—MARVAN—RŮŽIČKA 1969, P = PARYSKI 1951, Ps = POSPISIL 1950, R = ROSTAFINSKI 1881, 1927, SCH = SCHERFFEL 1910, SI = SIEMINSKA 1951, SI_1 = SIEMINSKA 1956, ST = STARMACH et KAVECKA 1966; cb = cryobiont, cp = cryophilous, cx = cryoxenous, r = red, b = black, g = green, y = yellow, p = pink, br = brown; ra = rare, c = common

* Table 1 and 2 see in part 1

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COMPARATIVE ALGOLOGICAL STUDIES IN SOME SOIL TYPES OF THE MÁTRA MOUNTAINS

By

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The most frequently occurring soil types have been examined algologically in the Hungarian Central Mountains — thus also in the Mátra Mts. The results allowed to make certain inferences as far as the species composition of the algal flora of some soil types and the connection between soil factors and algal flora are concerned. By using culture methods, of the 120 soil samples 35 species of algae have been identified with the following distribution: 16 green algae, 11 chrysophyceae and 8 diatoms. No blue-green algae were encountered.

When FRANCÉ (1913) created the concept "edaphon" analogous with plankton, he in fact gave name to all beings living in and on the surface of the soil. As ecological knowledge developed it was gradually recognized that the surface of the soil and the subterranean environment mean two different habitats primarily owing to light ecology. Consequently, the concept of edaphon had to be restricted to living beings inhabiting the soil itself. ELENKIN (Эленкин, 1936) and HOLLERBAH (Голлербах, 1936) used the word edaphon, ecologically quite correctly, in connection with blue-green algae already in this restricted sense.

Since algological literature was already hampered with terminological problems, the definition of terms became necessary. In his standard soil algological work, J. B. PETERSEN (1935), accepting FRITSCH's (1922) more or less delimited algal communities, construed them into a system based primarily on the water supply of the habitat. HOLLERBAH and SHTINA (Голлербах и Штина, 1969), in their soil algological handbook, surveyed and compared the earlier classifications and on these bases elaborated such a system which included all non-aquatic algal communities, precisely defining the characteristics of the units, what they called cenoses, and the meaning of the concept.

The word "community" used by PETERSEN (1935) and "сообщества водорослей" and "ценозы водорослей" and "группировки водорослей" and the algal synusium (HOLLERBAH and SHTINA, 1969) refer to the fact that the species composition of the algal flora of the soil is not random but defined and characterized by the biotope and the association. The expressions in various technical literature mean "community" in the broad sense of the word, and they are not identical with the concept "association" as used by BRAUN-BLANQUET (1932) and by DU RIETZ (1930, 1936).

Soil algology, as an independent branch of soil biology, with its special field, means of research and its tasks, developed at the end of the 1820s, later than the other branches of soil biology. One of the reasons for this was that the practical importance of soil algae in microbiology was far smaller than that of the other subterraneously living organisms. Another reason was that it was believed for some time that the metabolism of the autotrophic algae was impossible in the soil, and thus they occurred in the soil only in the form of spores.

In the last fifty years our knowledge gradually increased as far as the distribution of soil algae and their role in the life of the soil are concerned. It was found that they are extremely widespread and of paramount importance in the biological decomposition of rocks and in various biological processes enacted in the soil. Consequently, the soil algae are real elements of the ecosystem, and their importance and role vary according to the given ecosystem.

The association, as the unit of vegetation, comprises several stratocenoses in the soil. The soil has a unified ecology and a stable species combination, and may consist of several synusia, i.e. bacterial, actinomycetic, algal, etc., alliances.

The soil algal communities may appear as the components of various associations or independently (e.g. on rocks, natron flats, deserts), mainly in definite specific composition, the species are assumably interconnected with one another and with their environment, therefore, they are best be regarded as synusia.

The specific research methods of soil algology developed through the improvement and appropriate application of the prevailing methods in soil biology and soil sciences. The direct qualitative and quantitative methods invariably mean the direct microscopic examination of the soil: the soil samples are treated to yield preparations suitable for microscopic studies (HOLLERBAH, 1969; TCHAN, 1952).

The taxonomic identification of algal species can only be done by indirect methods, since most soil algae can be identified only by knowing all intermediate stages of development. Enrichment cultures, and cultures obtained by different liquid cultures inoculated into culture media assist in recognizing the stages of development characteristic for the species.

Cultures must be applied also in cases when only a small number of algal cells occurs in the soil and the direct analysis is unfeasible. In such cases, however, we should bear in mind the fact that the algae developed in cultures do not reflect the prevailing conditions found in natural communities. Thus the list of algae received by various culture procedures cannot be used to discover the quantitative regularities of an algal community in natural conditions, though may be suitable for the comparison of different soil types as

to their algal florae, and for an inquiry into the distribution of the individual species per soil type.

The study of epi- and subterranean algal communities at the level of our present knowledge comprises two closely related steps. First, the alga species inhabiting the examined soil type have to be known, and only after this may a study of the relationship between the quantitative conditions of algal communities and the environmental factors be launched.

In the present study I propose to attempt on the basis of algal lists, obtained during earlier investigations, to algologically characterize and compare some of the most frequently occurring soil types in the Mátra Mountains.

Material and method

The sample plot of the soil algological investigations lie along the highway connecting Mátraháza and Galyatető, removed several kilometres from each other in the submountaine beech forest where the most characteristic and most frequently occurring soil types are found.

Since the selected sample plots are in the zonal beech forest, there are no macroclimatic differences This region has a poor shrub level, nor is the grass cover very rich in species. Under such conditions, it may well be expected that the experienced algological differences result primarily from soil and microclimatic differences.

Table 1

Comparative table of soil types and associations occurring in the sample plots

Sampling place	Soil type	Association
Kislipót Mt.	nonpodzolized acidic brown forest soil	*Deschampsio-Luzulo-Fagetum*
Bagolykő I.	clay lessivated brown forest soil	*Melitti-Fagetum* (*caricetosum pilosae*)
Bagolykő II.	mull-ranker	*Mercuriali-Tiliaetum*
Parád	(Raman-type) brown earth	*Melitti-Fagetum* (*caricetosum pilosae*)

During the investigations I compared only the 0—5 cm upper soil layer, because in my experience this layer harbours the majority of algae. The depth distribution of soil algae would require another study and be published separately.

The soil samples were taken by an UNGER-type bacteriological soil borer (see Fig. 1), applying the random sampling method. In the unscrewable head-part of the soil borer numbered metal cylinders (capsules) may be inserted. The capsules, together with their rubber caps, were degerminated in a steam sterilizator prior to sampling. The soil sample is recovered together with the capsule, and sealed air-tight by the help of a rubber cap at both ends. Accordingly, a large number of soil samples could be carried back to the laboratory, in a comparatively small place and in safety.

Sampling was repeated from March to October once a month in 1973 and 1974 (a total of 120 samples were taken in 16 occasions). The soil samples were placed on the next day in sterile Petri dishes and, having sprinkled them with sterile water, put on shelves. On the surface of the moist soil and on the inner sides of the dishes green alga coats appeared in a matter of a few weeks.

The identification of the alga species was made partly from these soil cultures (enrichment cultures), and partly by the help of liquid and agar cultures obtained from the purification of the initial material.

Table 2

The results of physical and chemical analyses of the examined soil types (0—5 cm layer) (Cf. Kovács 1975)

Basic study data	Soil type			
	brown earth	clay lessivated brown forest soil	mull-ranker	nonpodzolized acidic brown forest soil
pH in water	6.2	5.9	6.4	4.2
Humus %	10.9	9.0	23.3	10.9
hy	6.5	4.7	10.4	9.5
Mech. comp.				
<0.002	30.5	10.8	4.0	9.4
0.002—0.02	33.8	53.4	50.5	54.5
0.02—0.2	25.1	25.0	13.7	6.2
0.2<	10.6	10.8	31.8	29.9

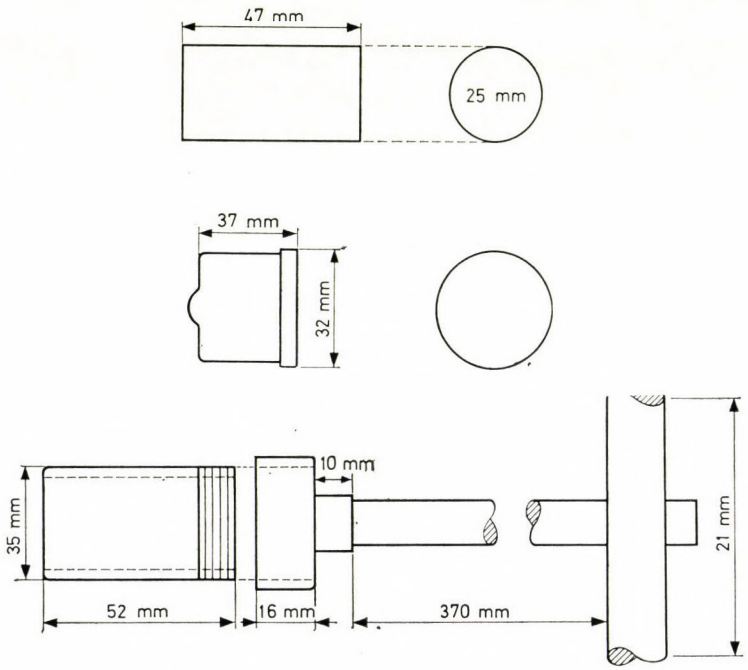

Fig. 1. Unger-type bacteriological soil borer

To the liquid cultures Detmer solution (diluted to 1 : 3) and Bold solution were added. In the case of agar cultures I always used Detmer solution with 1.5% agar-agar.

In order to compare the algal flora of different soil types, I made use of mathematical statistical methods. The most suitable biometrical method proved to be the one which makes it possible to compare two experienced frequency distributions, using several classes (Sváb, 1967).

During the investigations all four types of soil have been compared to each other, in each case the summarized results of the soil samples originating from two-two sampling plots have been grouped in the same class. The classes refer to the cultured algal species derived from the individual soil types, and the experienced frequency value of the individual algal species corresponds to their occurrence in the soil samples taken from the examined sampling plot.

When calculating significance, the value of χ^2 was obtained from—

$$\chi^2 = \frac{\Sigma \frac{aj^2}{aj + bj} - \frac{na^2}{na + nb}}{\frac{na}{na + nb} - \left(\frac{na}{na + nb}\right)^2}$$

where aj = frequency value in one of the soil types
bj = frequency value in the other soil type
na = sum of frequency values in one of the soil types
nb = sum of frequency values in the other soil type

The χ^2 values thus obtained was compared to the values of χ^2 (SVÁB l.c.) at the actual degree of freedom (DF k—1, where k equals the number of classes, i.e. the number of species in the two soil types). The algal floras of the two soil types were considered to be different when the significant difference (SD) was P% 5 or smaller.

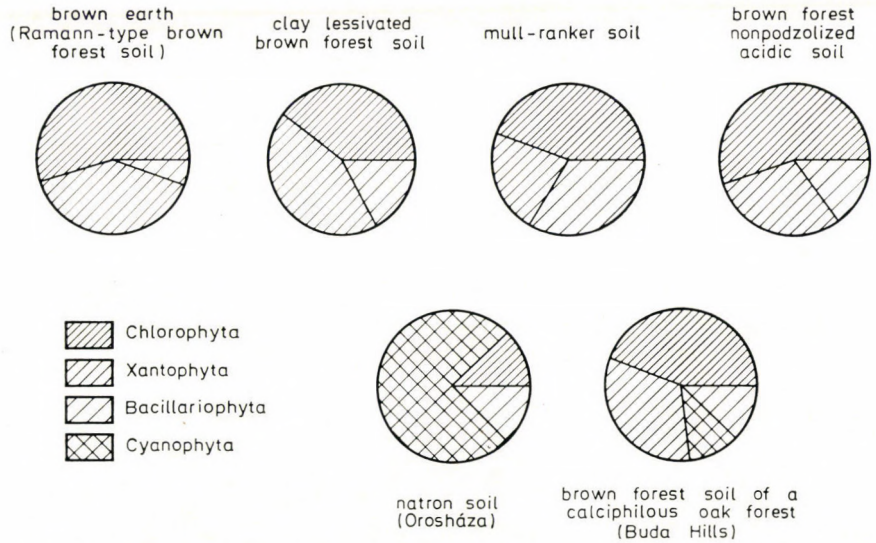

Fig. 2. The percentual proportion of the divisions of algae compared to one another in some soil types collected in the Mátra Mountains, and the further comparison of these data to those of a natron soil and of a brown forest soil in a calciphilous oak forest

The algological characterization of the examined soil types

The soil of the various associations, as the product and substrate of the ecosystem, changes according to association, each of them harbours a more or less different algal flora. The terricolous algae can be studied only under the microscope in a laboratory in contrast to the flowering and vascular cryptogamic plants, because the culture method applied here harbours a

number of possibilities for error, therefore these results should be used with caution.

During culture, the different algal species do not develop with the same intensity, therefore the prevailing quantitative conditions in the various cultures are not characteristic of natural conditions. The frequency of a given species in nature may be inferred from its occurrence per soil sample. To draw conclusions as far as the algological "productivity" of a soil type is concerned we should consider the ratio of the actually collected and the algologically positive samples. (Among the soil samples drawn in culture there are always some which do not yield any appreciable amount of algae even after a prolonged breeding, these are considered "negative" samples.)

Taking into account what has been said above, first the most frequently occurring algal species are listed in the following analyses then those found in at least two soil samples but in less than half of all samples, and finally those which have been ascertained only in one sample only.

The algological characterization of brown earth

The brown earth (*Ramman*'s brown forest soil) is widespread in the oak, hornbeam-oak and beech forests of the Hungarian Central Mountains. At the examined localities, the area is moist and the microclimate cool owing to their low situations. The soil is moist thoughout the year. To about a depth of 20 cm, the soil, without its litter layer, is a black, crumbling "A" level. According to laboratory examinations, the upper 10 cm has a humus content of about 10%, this, however, rapidly decreases downward. Soil reaction is weakly acidic (pH 6.2, gradually decreasing downward). (Cf. also KOVÁCS, 1975.)

The microscopic picture of the soil cultures shows a wide spectrum of species. In the different samples many species were found side by side, among them some species occurred in large individual numbers. The following species occurred in every sample and in comparatively great masses: *Botrydiopsis minor* (Schmidle) Chod., *Chlamydomonas* spp., *Chlorococcum humicolum* (Naeg.) Rabenh., *Monodus subterranea* B. Petersen, *Pleurochloris anomala* James and *Vischeria stellata* (Chod.) Pasch. (Figs 3, 4).

The following species appeared more rarely, in less than half of the samples: *Botrydiopsis intercedens* Pasch., *Chlorella vulgaris* Beyerinck, *Coccomyxa dispar* Schmidle, *Ellipsoidion oocystoides* Pasch., *Chlorhormidium* spp., *Keratococcus bicaudatus* Pasch., *Nephrodiella brevis* Vischer, *Pseudochlorella subsphaerica* Reisigl, *Stichococcus bacillaris* Naeg. and *Trochiscia reticularis* (Reinisch) Hansg.

The characteristic cells of *Botrydiopsis intercedens* Pasch. with iron-incrustation, and the reticulately thicked walls of *Trochiscia reticularis* (Reinisch) Hansg. (Fig. 3) were found only in this soil type.

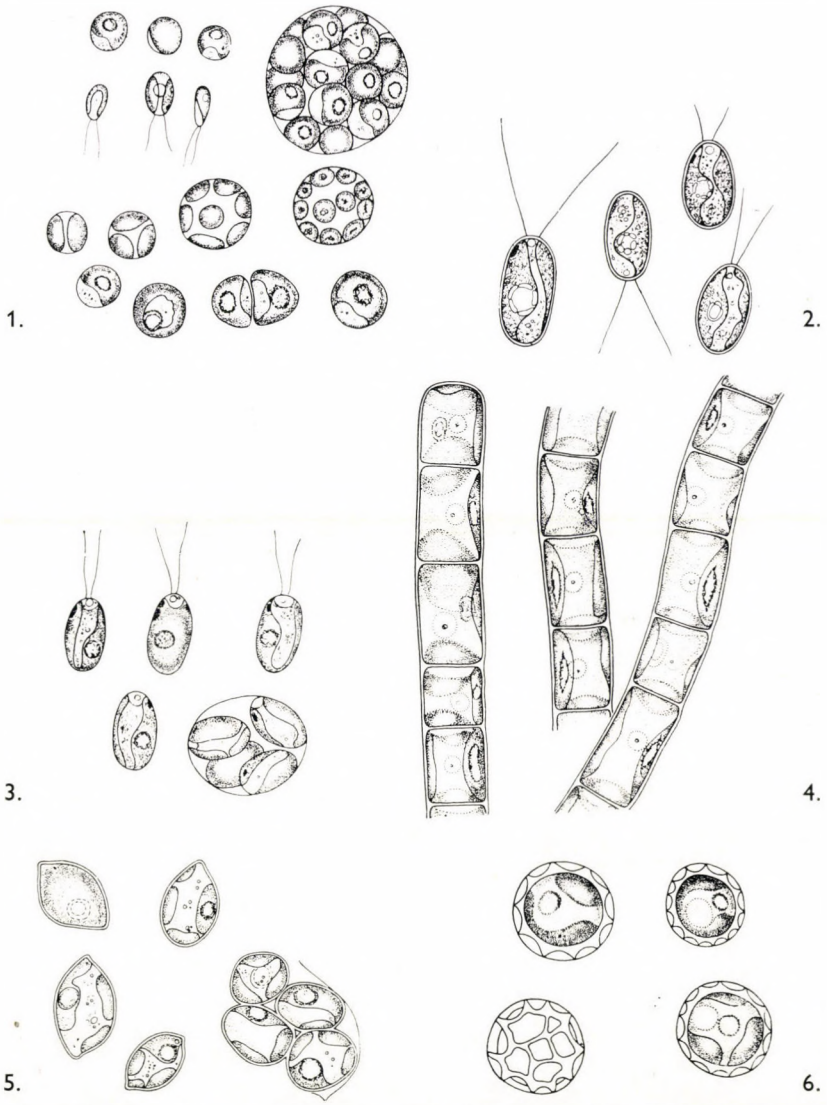

Fig. 3. Some characteristic and widespread soil algae from Mts Mátra. I. 1. *Chlorococcum humicolum* (Naeg.) Rabenh.; 2. *Chlamydomonas intermedia* Chod.; 3. *Chlamydomonas peterfii* Gerl.; 4. *Chlorhormidium flaccidum* (Kütz.) Fott; 5. *Oocystis asymmetrica* W. West; 6. *Trochiscia reticularis* (Reinisch) Hansg.

The algological characterization of clay lessivated brown forest soil

This is the most wide spread soil type not only in the Mátra Mountains but also in the whole of the Hungarian Northern Mountains. It occurs in the oak, hornbeam-oak and in the beech zones, too. Among the examined soil types of the Mátra Mountains it is the most compact soil type with the lowest

amount of humus. Owing to the southern exposition of the sample plot, its microclimate is dry and warm, the soil desiccates quickly. At the foot of the trees devoid of a litter cover, the soil frequently cracks. The upper 0—5 cm layer is a dark brown, loose "A_0" level. Below it, we find level "A_1", of a light brown colour and of a porous structure mixed with rocks, followed further down by level "A_2", lighter brown and of a more compact structure. According to laboratory examinations, the highest humus content is found in the upper 5 cm layer (9%), the quantity of which rapidly decreases with depth and in the 5—15 cm layer its amount hardly reaches 1%. Soil reaction is weakly acidic (pH 5.9, but in level "A_1" it decreases to 4.9). (Cf. KOVÁCS l. c.)

The algological picture of the cultures was characterized by the clavate spinous cells of *Vischeria stellata* (Chod.) Pasch. It occurred in almost every sample and its individual numbers surpassed those of any other species throughout the year (Fig. 4).

Botrydiopsis minor (Schmidle) Chod. and *Chlamydomonas intermedia* Chod. appeared in fewer samples and in smaller individual numbers (Figs 3, 4).

Some other species, as *Chlorococcum humicolum* (Naeg.) Rabenh., *Hantzschia amphyoxis* (Ehr.) Grun. and *Pinnularia* spp. appeared rarely, in one sample only. In cognizance of the rich diatomous flora of the mull-ranker soil above the sampling plot, *Pinnularia borealis* Ehr., *P. intermedia* Lagerst. and *P. obscura* Krasske were probably washed down by rain water to this lower area.

The algological characterization of mull-ranker soil

Owing to the effect of the steep northern slope on the examined plot, soil motion is quite pronounced. The torrential rainwater, the continuous passage of smaller or larger animals contribute to the downward motion of the soil. On small areas covered with vegetation and at the foot of trees the motion is slower and the cool and moist soil rich in nutritive materials, accumulates (in some places to a depth of 40—80 cm). In consequence of the microclimate, the soil temperature is by 4—5 °C lower than elsewhere, i.e. on the ridge. As a result of the continuous and slow mixing, the soil is homogenous in all samples, no levels are to be found. Immediately below level "A", the parent rock appears. The humus of the 30—60 cm thick soil layer is mull-like, black in colour, loose in structure, and moist even in the driest period of the year. According to laboratory examinations, the soil is poor in clay, rich in humus (23%), the soil reaction weakly acidic (pH 6.2—6.5). (Cf. KOVÁCS l.c.)

The algafloristic picture of the mull-ranker soil is characteristic: large masses of moving diatoms are present. In most of the samples *Vischeria stel-*

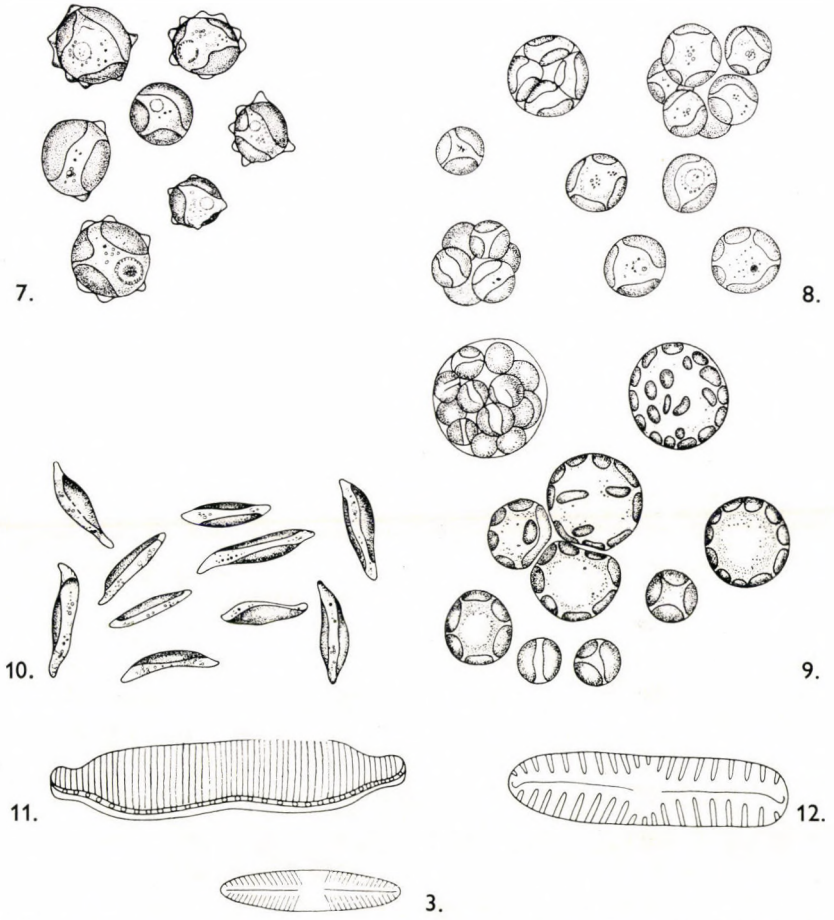

Fig. 4. Some characteristic and widespread soil algae from Mts. Mátra. II. 7. *Vischeria stellata* (Chod.) Pasch.; 8. *Pleurochloris anomala* James; 9. *Botrydiopsis minor* (Schmidle) Chod.; 10. *Chlorocloster terrestris* Pasch.; 11. *Hantzschia amphyoxis* (Ehr.) Grun.; 12. *Pinnularia borealis* Ehr.; 13. *Navicula vaucheri* B. Petersen; (10 μm = = 10 mm in the picture)

lata (Chod.) Pasch., *Hantzschia amphyoxis* (Ehr.) Grun. and *Navicula vaucheri* B. Petersen were quite common, though *Navicula borrichii* B. Petersen, *Pinnularia intermedia* Lagerst. and *P. obscura* Krasske likewise occurred in many samples and in comparatively large individual numbers (Fig. 4).

On the other hand, *Chlorococcum humicolum* (Naeg.) Rabenh., *Dactylococcus* sp., *Heterotrhix exilis* Pasch., *Chlorhormidium flaccidum* (Kütz.) Fott, *Nephrodiella brevis* Vischer, *Oocystis asymmetrica* W. West occured in small individual numbers and each in one sample only.

Navicula vaucheri B. Petersen and *N. borrichii* B. Petersen were encountered only in this type of soil.

The algological characterization of the nonpodzolized acidic brown forest soil

The upper acidic soil, rich in mull-humus, differs both in colour and in structure from the layer immediately below it. The thin black upper "A_0" level (0—3 cm), rich in roots and mycelia is sharply delimited from the lower, yellow, rocky "A_1" level. According to laboratory examinations, the upper 0—3 cm layer is rich in humus (22%), acidic in reaction (pH 4.0), clayey (10—20%) but poor in calcium. Owing to its high humus content, it is generally moist. (Cf. KOVÁCS l.c.)

The algafloristical picture of the soil cultures shows large masses of intertwinning filamentous green algae and great numbers of the green globules of *Chlamydomonas* colonia and of the cells of *Chlorococcum humicolum* (Naeg.) Rabenh. The following species also occurred in almost every sample and generally in large individual numbers: *Chlorhormidium flaccidum* (Kütz.) Fott, *Chlorhormidium crenulatum* (Kütz.) Kom., some other *Chlorhormidium* and *Chlamydomonas* species, together with *Monodus subterranea* B. Petersen and *Chlorococcum humicolum* (Naeg.) Rabenh. (Figs 3, 4).

Chlorocloster terrestris Pasch., *Pseudochlorella subsphaerica* Reisigl, *Stichococcus bacillaris* Naeg., *Ellipsoidion oocystoides* Pasch. were encountered in some of the samples only, in small or in moderate numbers.

The following species appeared only in one sample each and in a very small individual numbers: *Chlamydomonas intermedia* Chod., *Coccomyxa dispar* Schmidle, *Chlorhormidium nitens* (Hansg.) Kom., *Pleurochloris anomala* James, *Tribonema minus* (Wille) Hazen, *Vischeria stellata* (Chod.) Pasch., *Hantzschia amphyoxis* (Ehr.) Grun., *Navicula mutica* Kütz. and *Pinnularia borealis* Ehr.

Three species were found only in this type of soil: *Chlorocloster terrestris* Pasch., *Chlorhormidium nitens* (Hansg.) Kom. and *Tribonema minus* (Wille) Hazen.

The majority of the species occurring in the soil samples taken in the Mátra Mountains belong in the genera of *Chlorophyceae* and *Xanthophyceae*. In one of my earlier studies concerning the Buda Hills, I reached the same conclusion (KOMÁROMY, 1969a, 1969b).

Similar results were found by HINDÁK (1970) in the Czechoslovakian hornbeam-oak zones. HOLLERBAH and SHTINA (1969), collating their own results and numerous literature data, came to the conclusion that in the soils of the temperate forest zones mainly green algae are found, primarily species of *Chlamydomonas*, *Coccomyxa*, *Chlorella*, *Chlorhormidium*, *Stichococcus*, *Chlorococcum* and *Pleurococcus*.

According to SHTINA's (1961) data, the biomass produced by the algae in the various forest soils is much smaller (20 kg/ha) than in the field soils (300 kg/ha).

The percentual distribution of the algal divisions occurring in the examined

Table 3

The experienced frequency distribution of cultured algae, occurring in some soil types of the submountane beech zone of the Mátra Mountains

Species	Brown earth	Clay lessivated brown forest soil	Mull-ranker soil	Nonpodzolized acidic brown forest soil
Chlorophyta				
Chlamydomonas intermedia Chod.	0	3	0	1
Chlamydomonas peterfii Gerl.	0	0	1	0
Chlamydomonas sp.	16	1	1	5
Chlorella vulgaris Beyerinck	1	0	1	0
Chlorhormidium flaccidum (Kütz.) Fott	1	1	1	4
Chlorhormidium crenulatum (Kütz.) Kom.	1	0	0	2
Chlorhormidium nitens (Hansg.) Kom.	0	0	0	1
Chlorhormidium sp.	0	0	0	4
Chlorococcum humicolum (Naeg.) Rabenh.	7	2	2	5
Coccomyxa dispar Schmidle	1	0	0	1
Dactylococcus sp.	1	1	2	0
Keratococcus bicaudatus Pasch.	1	0	0	1
Oocystis asymmetrica W. West	0	0	1	0
Pseudochlorella subsphaerica Reisigl	1	0	1	2
Stichococcus bacillaris Naeg.	2	0	0	2
Trochiscia reticularis (Reinisch) Hansg.	1	0	0	0
Xanthophyta				
Botrydiopsis intercedens Pasch.	4	0	0	0
Botrydiopsis minor (Schmidle) Chod.	11	3	0	0
Chlorocloster terrestris Pasch.	0	0	0	1
Ellipsoidion oocystoides Pasch.	1	0	0	2
Heterothrix exilis Pasch.	0	0	1	0
Monodus subterranea B. Petersen	11	0	0	4
Nephrodiella brevis Vischer	2	0	1	0
Pleurochloris anomala James	7	0	0	1
Pleurochloris meringensis Vischer	3	0	1	0
Tribonema minus (Wille) Hazen	0	0	0	1
Vischeria stellata (Chod.) Pasch.	12	6	4	1
Bacillariophyta				
Hantzschia amphyoxis (Ehr.) Grun.	0	2	4	1
Navicula borrichii B. Petersen	0	0	1	0
Navicula vaucheri B. Petersen	0	0	5	0
Navicula mutica Kütz.	2	0	0	1
Pinnularia borealis Ehr.	0	1	0	1
Pinnularia intermedia Lagerst.	0	1	1	0
Pinnularia obscura Krasske	0	1	1	0
Pinnularia sp.	0	1	1	0
Total	20	12	18	20

soil types is shown in a circle diagram. For comparative purposes, I also present Kiss' algafloristical data, obtained in 1972, from the natron soil of the loess region in Békés—Csanád (Orosháza), as well as my own, originating from 1969, from a calciphilous oak forest on brown forest soil (Fig. 2).

The quantitative examination of algal species occurring in the different soil types

During the comparison of the algal floras of the different soil types I attempted to resolve whether the combined occurrence of certain soil types and algal species is coincidental or the individual algal species significantly associate with the given soil types.

The frequency distribution of algal species per soil type is shown in Table 3. The results of significance calculations are given in Table 4.

Table 4

The results of significance calculations on the experienced frequency distribution of algal species cultured from different soil types

Compared soil types	x^2	DF	SD P% values
Mull-ranker — brown earth	73.6	28	0.1
Brown earth — brown forest nonpodzolized acidic soil	57.0	26	0.1
Brown forest nonpodzolized acidic soil — mull-ranker	52.9	31	1.0
Clay lessivated brown forest soil — brown forest nonpodzolized acidic soil	35.8	24	5.0
Clay lessivated brown forest soil — mull-ranker	26.8	20	10.0
Clay lessivated brown forest soil — brown earth	37.4	25	10.0

If, according to international practice, we accept the limit value of the significant difference as SD P% 5, then the algal communities of two soil types are different from each other if the obtained value is smaller than or just reaches P% 5.

In evaluating the tabulated data we may establish that, apart from two cases, there is a significant difference between the algal communities of the different soil types.

The mull-ranker soil, the brown forest nonpodzolized acidic soil and the brown earth strongly differ from one another on the basis of laboratory examinations (cf. KOVÁCS l.c.). In the algal flora of the two pairs of soil types: mull-ranker—brown forest soil and the brown forest nonpodzolized acidic soil—brown forest soil, significant difference of 0.1% was found, assumably connected with various soil characteristics.

Of course, the identical level of significant differences does not preclude that the components of an algal community be different, excepting *Vischeria stellata* (Chod.) Pasch. which occurred in great frequency in all three soil types.

Both the mull-ranker and the clay lessivated brown forest soil differ similarly of the previous ones in several soil factors fundamentally from

the brown forest nonpodzolized acidic soil. The algal flora of these soils shows significant difference as far as the frequency distribution of the individual species is concerned. The differences may be explained by the differences in the frequency distribution, e.g. *Chlorococcum humicolum* (Naeg.) Rabenh., *Chlorhormidium flaccidum* (Kütz.) Fott, *Vischeria stellata* (Chod.) Pasch., *Hantzschia amphyoxis* (Ehr.) Grun. On the other hand, there are species which occur only in one type, or in the other two types of soil, e.g. *Chlorhormidium crenulatum* (Kütz.) Kom., *Chlorhormidium nitens* (Hansg.) Kom., *Chlorhormidium* sp., *Keratococcus bicaudatus* Pasch., *Stichococcus bacillaris* Naeg., *Chlorocloster terrestris* Pasch., *Ellipsoidion oocystoides* Pasch *Monodus subterranea* B. Petersen in the acidic forest soil, while *Dactylococcus* sp., *Pinnularia intermedia* Lagerst., *Pinnularia obscura* Krasske and *Pinnularia* sp. occur only in the other two types of soil (cf. Table 3).

Parallel with the increase of hydrogen ion concentration of the soil, the role of the subterranean fungi rapidly increases, while the bacteria and other microorganisms retreat the background (Bohus and Babos, 1973). Similarly, the terricolous actinomyces reach their highest productivity in acidic soil (McLennan et al., 1954; Brown, 1958). In the brown forest nonpodzolized acidic soil the algal flora is much richer compared to the other soil types, and especially the *Chlorhormidium* species predominate.

The mull-ranker soil and the clay lessivated brown forest soil differ from each other in numerous ecological factors (humus and moisture content, temperature, soil acidity, soil cover, biological activity, etc.) (cf. Kovács l.c.). The two examined areas are adjacent (the northern and southern slopes of Bagolykő), the two soil types meet each other. Rain water runs down from the mull-ranker soil rich in diatoms, and the flowing water carries numerous algal cells with it which settle at the lower points for a shorter or longer period of time. When comparing the algal floras of the two soil types, no significant difference could be found, owing to the mixing of the floras. Consequently, when comparing two soil types from an algological point of view, one should avoid the investigation of sample plots meeting in space.

I did not expect any essential difference between the brown earth and the clay lessivated brown forest soil as far as the algal flora was concerned (see Table 3). The two types of soil are close to each other in several characteristics (cf. Kovács l.c.). Even the vascular vegetation of the two sampling plots, lying several kilometres from each other, is very similar (*Melitti-Fagetum* association *caricetosum pilosae* facies). A pronounced difference occurs only in water supply, reflected in the richer algal flora of the brown earth. Both in the number of the soil samples and in the most frequently occurring species, the two soil types are identical: *Chamydomonas* sp., *Chlorococcum humicolum* (Naeg.) Rabenh., *Botrydiopsis minor* (Schmidle) Chod., *Vischeria stellata* (Chod.) Pasch.

The following inference can be drawn from these investigations: the algal communities of different soil types with diverging ecological characteristics differ from one another to a degree ascertainable for the difference between the ecological characteristics of the individual soil types.

The analysis of the examined soil types with respect to the occurrence of algal species

If the algal communities of the various soil types are examined with respect to the species concerned (see Table 3), in the species may be relegated into three large groups.

The first group includes species occurring in every examined soil type (11.4% of the total number). To this category belong *Chlorococcum humicolum* (Naeg.) Rabenh., *Chlorhormidium flaccidum* (Kütz.) Fott, *Vischeria stellata* (Chod.) Pasch. and *Hantzschia amphyoxis* (Ehr.) Grun. Among them, *Vischeria stellata* (Chod.) Pasch. and *Chlorococcum humicolum* (Naeg.) Rabenh. commonly inhabit nonaquatic biotopes. They not only appear on and in the soil, but are frequently found on the trunks of trees, on litter, on stones, on fallen pieces of branches and even on boardings as well. On the other hand, *Chlorhormidium flaccidum* (Kütz.) Fott and *Hantzschia amphyoxis* (Ehr.) Grun. may be encountered both in aquatic and in nonaquatic communities.

The frequency of algal species per soil type is not the same. According to my investigations, the most frequently occurring algal species per soil type were as follow: *Chlorococcum humicolum* (Naeg.) Rabenh. in brown forest soil, *Chlorhormidium flaccidum* (Kütz.) Fott in acidic soil, *Vischeria stellata* (Chod.) Pasch. in brown forest soil and in clay lessivated brown forest soil, *Hantzschia amphyoxis* (Ehr.) Grun. in mull-ranker soil. Species assigned to this group occurred in more than half of all examined soil samples. Accordingly these species should not be regarded as specific for the soil types concerned.

Species occurring in two or at most in three soil types, comprise the second group. They are characteristic terricolous organisms in the Mts Mátra. In investigating their frequency per soil type, it may be stated that in some of the soil types they occur frequently (present in about half of the samples) while in others they occur only sporadically (only in one sample). Thus, e.g. *Botrydiopsis minor* (Schmidle) Chod., *Monodus subterranea* B. Petersen, *Pleurochloris anomala* James and *Pleurochloris meringensis* Vischer occur in brown earth, the various species of diatoms in mull-ranker soil: in contrast to these, *Chlorhormidium* species, *Stichococcus bacillaris* Naeg. and *Monodus subterranea* B. Petersen occur in acidic soil, whereas *Chlamydomonas intermedia* Chod. and *Botrydiopsis minor* (Schmidle) Chod. are frequent in clay lessivated brown forest soil.

The fact that these species are frequent in one type of soil and occur

sporadically in the other suggests that species characteristic of the soil types should be sought among them (see Tables 3 and 4). About 60% of the species found in the examined soil types belong into this group.

The third group includes species occurring only in one type of soil. Their frequency is generally low, appearing in one sample only (28.5% of the total number of species). Little is known concerning the occurrence of *Trochiscia reticularis* (Reinisch) Hansg., *Oocystis asymmetrica* W. West and of *Chlorhormidium nitens* (Hansg.) Kom. in the soil. On the other hand, *Heterothrix exilis* Pasch. is a frequent soil alga, but the other members of the genus live exclusively in aquatic biotopes. Many *Navicula* species are terricolous, but *Navicula borrichii* B. Petersen and *Navicula Vaucheri* B. Petersen do not belong to the frequently occurring species. It is quite likely that these species, though rarely and for only a short period of time, are abundant, but on the basis of the examined soil samples they are not suitable for the characterization of soil types.

Summary

In cognizance of the soil ecological characteristics concerning the examined soil types (cf. Kovács 1975 and Table 2) the following conclusions can be drawn as far as the results of the soil algological investigations are concerned.

a) The brown forest nonpodzolized acidic soil, with its slow nutrient cycle and low biological activity, is richer in species than the mull-ranker soil with its good nutrient cycle and high biological activity. 55% of the species in the acidic soil, and 70% of them in the mull-ranker soil were occurring sporadically, i.e. these species occurred only in one soil sample. In the acidic soil, 20% of the total number of species, in the mull-ranker soil 16%, were found which occurred in more than half of the total number of samples. These data imply that the algal communities reach similarly to the terricolous actinomyces and fungi, their highest species and individual numbers in the acidic soil types.

b) Soil-ecologically different but spatially adjacent soil types have similar terricolous algal communities.

c) Floristically and soil-ecologically similar but spatially separated soil types (sampling plots lying several kilometres from one another) have again similar algal communities.

d) In the course of the algological analysis of different soil types I found that the majority of species comprising the terricolous algal communities are characteristic epi- and subterranean algae, and that their frequency per soil type is not the same.

e) The majority of algal species originating from soil samples collected in the Mátra Mountains belongs to genera of the divisions *Chlorophyta* and

Xanthophyta. This finding corresponds with earlier observations according to which the algal flora of forest ecosystems is generally of the *Chlorophyta*-type, while the algal floras of rocky and field ecosystems are of the *Cyanophyta*-type.

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SPORE MORPHOLOGICAL STUDIES ON RECENT EUROPEAN ENCALYPTA SPECIES

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Comprehensive spore morphological investigations of European *Encalypta* species have been carried out with the aid of light and scanning electron microscopy. The distinct morphological differences of spores within the genus may allow the supposition that the recent classification of the *Encalypta* genus or even the *Encalyptaceae* family contains some taxonomical and phylogenetical uncertainties. Detailed palynological description of the spores of nine *Encalypta* species is given with a view to solve these taxonomical questions. The taxonomy of *Encalyptaceae* is yet incompletely understood and further palynological research covering the entire family is needed.

Introduction

It has been well known for a long time that the spores of different *Encalypta* species have very distinct differences both in size and in characteristics visible even under the light microscope (LM).

Studying the morphology of recent moss spores (BOROS—JÁRAI-KOMLÓDI, 1975) a well-marked contrast is to be found between the two examined *Encalypta* species (*E. ciliata*, *E. streptocarpa*). These species highly differ from each other in size, in structure and also in ornamentation. These morphological dissimilarities have drawn our attention to this genus.

In order to contribute to some extent to the elucidation of some taxonomical and palynological questions in this group, the authors have decided to carry out a comparative spore morphological examinations of recent European *Encalypta* spores.

Not adequately illustrated comparative spore morphological works of this genus though some descriptions and illustrations have been published so far by various authors (ERDTMAN, 1957; 1965; SAVICZ-JUBITZKAJA—SMIRNOVA, 1970; DICKSON 1973; BOROS—JÁRAI-KOMLÓDI, 1975).

The present study does not have only taxonomical but palaeobotanical significance, too. Namely, the examined species are mainly distributed recently in arctic-alpine and circumboreal regions and it can be supposed that these species were wide-spread during the ages when a colder climate prevailed, thus, fossil spores of *Encalypta* are expected to come forward from the Pleistocene and even from older strata.

Some records of fossil spores are already known, e.g. those of *Encalypta rhabdocarpa* from the Late Pleistocene of Alaska (DICKSON, 1973), *E.* cf. *vulgaris* from the Late Pleistocene of Siberia (ABRAMOVA et al., 1965), and *Encalyptosporites pliocenicus* from the Neogene of Hungary (NAGY, 1968). Presumably the oldest finding of fossil spores of *Encalypta* was found in the Devonian of Canada if the spores described as *Emphanisporites* in fact belong to the *Encalypta* genus (ERDTMAN, 1969).

In addition to the fossil spores, well-preserved macrofossils of *Encalypta* have been encountered in Pleistocene strata, for example, macrofossils of *E. alpina* in Denmark (HESSELBO, 1910), *E. vulgaris* in interglacial strata, of Weimar (GAMS 1932), *E. rhabdocarpa* in several localities of England (WARREN, 1912; JESSEN, 1949), and in Poland (SZAFRAN, 1952), and some unrecognizable species of *Encalypta* in England (DICKSON, 1964).

All these findings allow to suppose that the fossil spores of other *Encalypta* species are also to be expected from the Pleistocene and even from the older geological strata. For this reason it may also prove useful to study this genus from the palaeobotanical point of view.

The palynological part of this paper is the work of M. JÁRAI-KOMLÓDI, while the bryological part was compiled by S. ORBÁN. The photomicrographs have been taken by M. JÁRAI-KOMLÓDI.

Material and methods

Spore material was obtained from the Herbarium of the Hungarian Natural History Museum and the Herbarium of Á. BOROS, deposited at the same place.

For the light microscopy (LM) the spore samples were acetolyzed (ERDTMAN, 1952) and mounted in glycerin jelly. A Carl Zeiss NU Photomicroscope was used with planachromate ×100 (N.A. 1.30) objective. Twenty measurements of spore size were made on each sample.

For the scanning electron-microscopic study, the material was also acetolyzed, then coated with evaporated gold. The scanning electron micrographs (SEMG) were taken with the ISM-50 scanning electron microscope (SEM) at the Eötvös Loránd University, Budapest. We wish to thank Vera TAKÁCS for skilful technical assistance in taking SEMGs.

The terminology follows that of ERDTMAN (1970).

Results and discussion

1. Taxonomy, distribution and ecology of the genus Encalypta

The genus *Encalypta* belongs to the order of *Pottiales*, suborder of *Encalyptinales* and to the family of *Encalyptaceae* (with two genera: *Encalypta* and *Bryobrittonia*). The latter is related to *Encalypta* by its sporophytic characters but well separable from it by the gametophytic characters. STEERE (1953) stated that the genus *Bryobrittonia* has belonged to *Encalyptaceae*.

Mostly on the basis of sporophytic characters *Encalypta* can be divided

into sections. Concerning the different divisions only the most important ones are referred here. NEES et al. (1827) described sections I. *Aperistomae* and II. *Peristomae*, based obviously on the absence or presence of peristomium. C. MÜLLER (1848—49) and LINDBERG (1879) separated the sections of *Rhabdotheca* and *Psilotheca* on the basis of the character of spore capsule.

KINDBERG (1897) established five sections considering both the former divisions and many other characters of sporophyte: I. *Streptotheca*, II. *Diplolepis*, III. *Rhabdotheca*, IV. *Pyromitrium*, V. *Xanthopus*. This has essentially been used until today but the order of the sections has been changed by the different authors.

For example the KINDBERG's division was modified by BROTHERUS (1924) as follows: I. *Pyromitrium*, II. *Xanthopus*, III. *Rhabdotheca*, IV. *Diplolepis*, V. *Streptotheca*. PODPERA (1954) again modified the division of *Encalypta*: I. *Pyromitrium*, II. *Rhabdotheca*, III. *Xanthopus*, IV. *Diplolepis*, V. *Streptotheca*.

These different divisions may have supposedly been established on the basis of certain phylogenetic reasons connected with the structure of the peristomium. In section *Pyromitrium* there is no peristomium and the same applies to some species of section *Rhabdotheca*, while the other species of this section have a single-row peristomium. Both in section *Diplolepis* and *Streptotheca* the species have double-row peristomium.

In this paper none of these divisions was used. We grouped the species according to certain principles of spore morphology. Attention is drawn to the morphological similarities and differences among the examined species. But it is hardly possible to make any further divisions since only the European species of genus have been investigated. So, we have to wait with our taxonomical suggestion until the spore morphological study of the whole family will have been carried out. In this case the relationship of the genera *Encalypta* and *Bryobrittonia* or those of the different species will be solved rather on the basis of phylogenetic reasons than in the different classifications used so far.

The chromosome numbers of six out of nine investigated species are known: *Encalypta alpina* 14, *E. rhabdocarpa* 26, *E. procera* 27 (STEERE, 1954); *E. vulgaris* 26 (VISOTSKAYA, 1967; SMITH—NEWTON, 1968); *E. ciliata* 13 (ANDERSON—CRUM, 1958; SMITH—NEWTON, 1968); *E. affinis* 13 (ANDERSON—CRUM, 1958).

The *Encalypta* species living also in Europe are mainly distributed in the northern hemisphere of the whole world. The species have circumboreal or boreal-arctic range, inhabit alpine, subalpine and montane regions. Some of them have disjoint area in Australia and South Africa.

The *Encalypta* species mainly live on limestone and other kinds of rocks containing lime (andesite, basalt, gabbro, marl, dolomite) rarely on lime-deficient rocks (granite, gneiss), also on humous debris in clefts of rocks and

on calcareous soils and sediments (loess, loam, sand). They are known as xerophyte, meso-xerophyte and mesophyte, heliophilous, helio-sciophilous and rarely as sciophilous species.

2. *Description of species investigated*

Encalypta ciliata (Hedw.) Hoffm. (Figs 1—9)

Synonym: *E. laciniata* Lindb.
Area: Circumboreal, disjoint in Australia and South Africa. Mainly in mountainous regions.
Ecology: Mesophyte, helio-sciophilous, saxi-terricolous, slightly acidophilous. Mostly on soils and rocks rich in lime, sometimes on lime-deficient habitats, too.
Spore formation: Sporogonia are regularly developed. Fossil spores are rarely to be expected.
Cytotaxonomy: Diploid, n = 13.

Spore morphology:

Size: Mean value 37 μm, size range 40—34 μm.

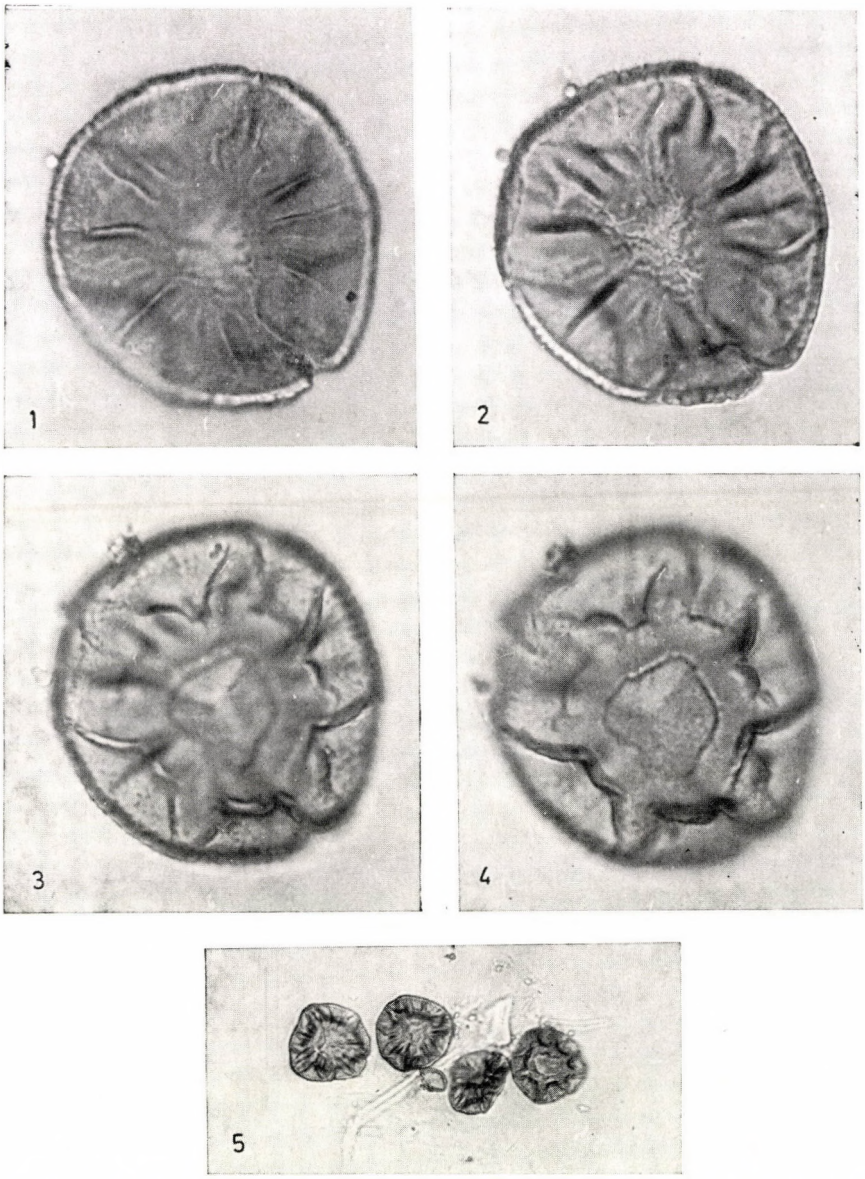
Shape and structure: Spores spheroidal. Trilete. Laesura arms often indistinct, narrow, not-thickened, one arm about 6 μm long. Exine about 2 μm thick, containing a very distinct "sexinous" and a "nexinous" part.

Ornamentation: There are great differences in ornamentation between the two faces of the spore. The outer part of exine exhibits a very characteristic appearance forming in the distal face a large (10—12 μm in diameter) central "brochus" with 5—6 radial murus-like arms running to the amb. On SEMGs of spores it is well visible (already at $\times$6000 magnification) that the bottom of "brochus" is finely pitted. Arms form 5—7 marginal meshes. The breadth of muri about 5—7 μm, the height about 4 μm. In the proximal face muri grow thinner into wrinkles running to the central part and are amalgamated into a large central shield in the middle of which the trilete mark can be seen. Near the amb a system of about 10—14 murus-like arms and of several marginal meshes develop. In both faces of the spore sexine consists of irregularly angular, united verruca-like elements.

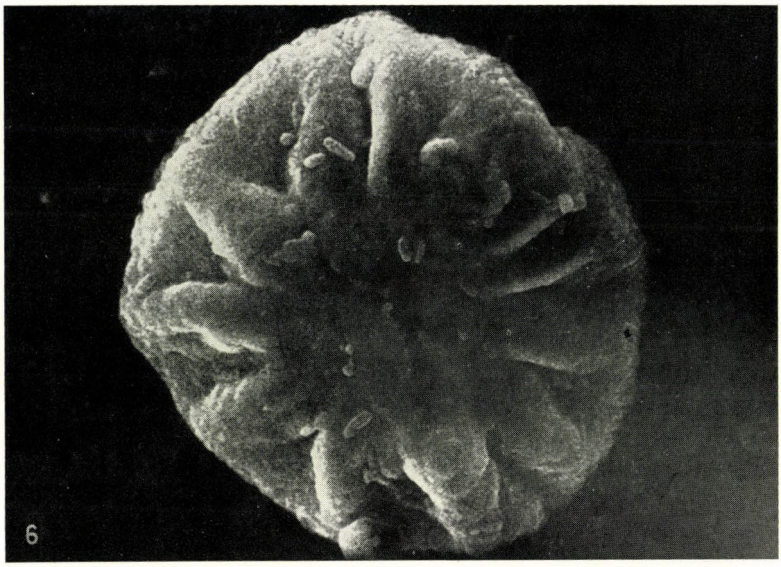
Locality: The Bükk Mts, near Szarvaskő (Hungary); Á. Boros, 1960/*102352*.

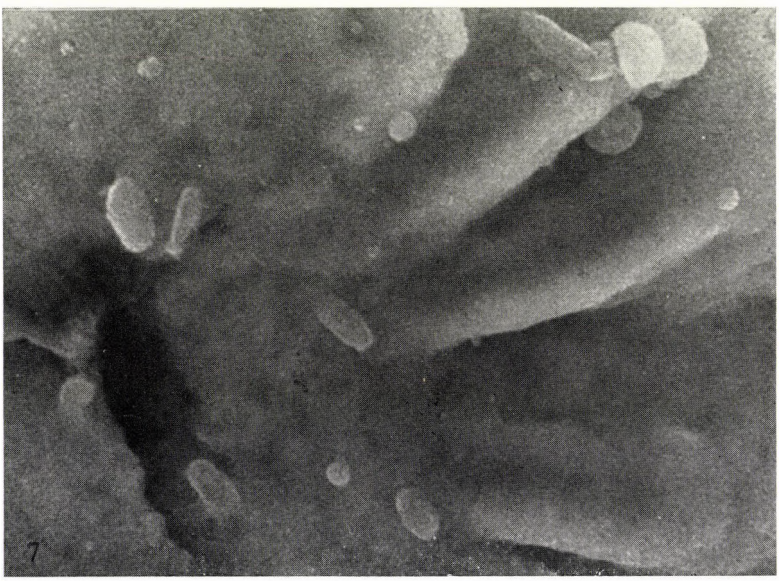
Encalypta rhabdocarpa Schwaegr. (Figs 10—23)

Synonym: *Leersia rhabdocarpa* Lindb.
Area: Circumboreal, arctic-alpine. Mostly in alpine region, sometimes in lower zones, too.
Ecology: Xerophyte, heliophilous, saxicolous, calciphile. On humus in clefts of limestone and calcareous rocks (rich in lime).
Spore formation: Sporogonia are regularly developed. Fossil spores are hardly to be expected.
Cytotaxonomy: Diploid, n = 26.

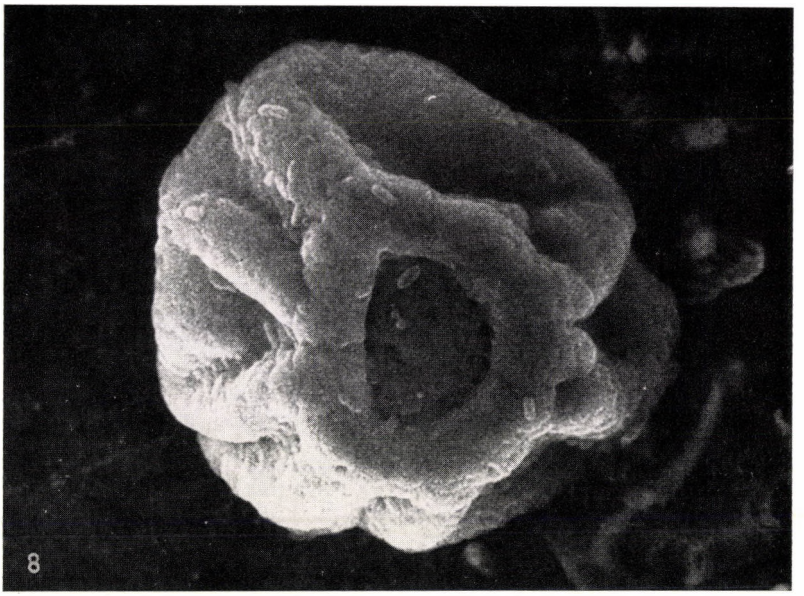


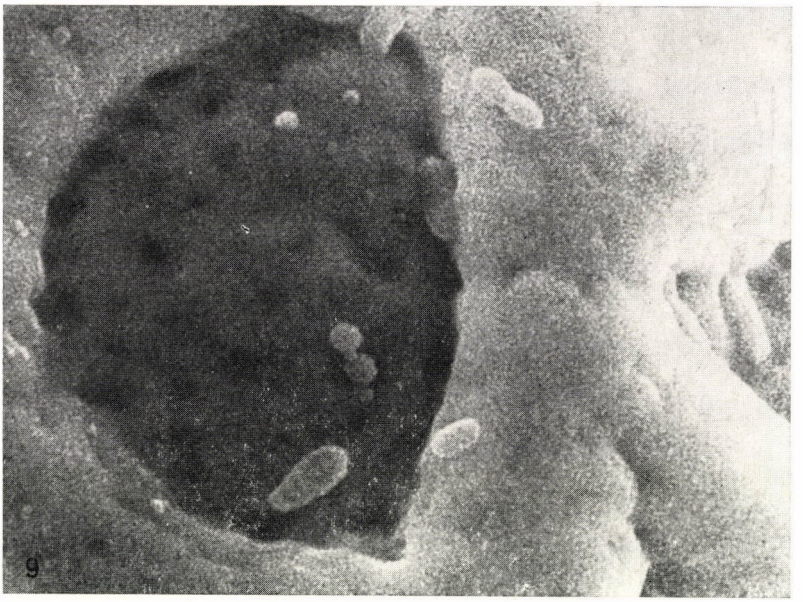
Figs 1—9. Encalypta ciliata (Hedw.) Hoffm. 1—2. Proximal face, *LMG* (×1000). 3—4. Distal face *LMG* (×1000). 5. Group (proximal and distal face), *LMG* (×250). 6. Proximal face, *SEMG* (×2000). 7. Proximal face, central part, *SEMG* (× 6000). 8. Distal face, *SEMG* (×2000). 9. Distal face, central brochus, *SEMG* (×6000)



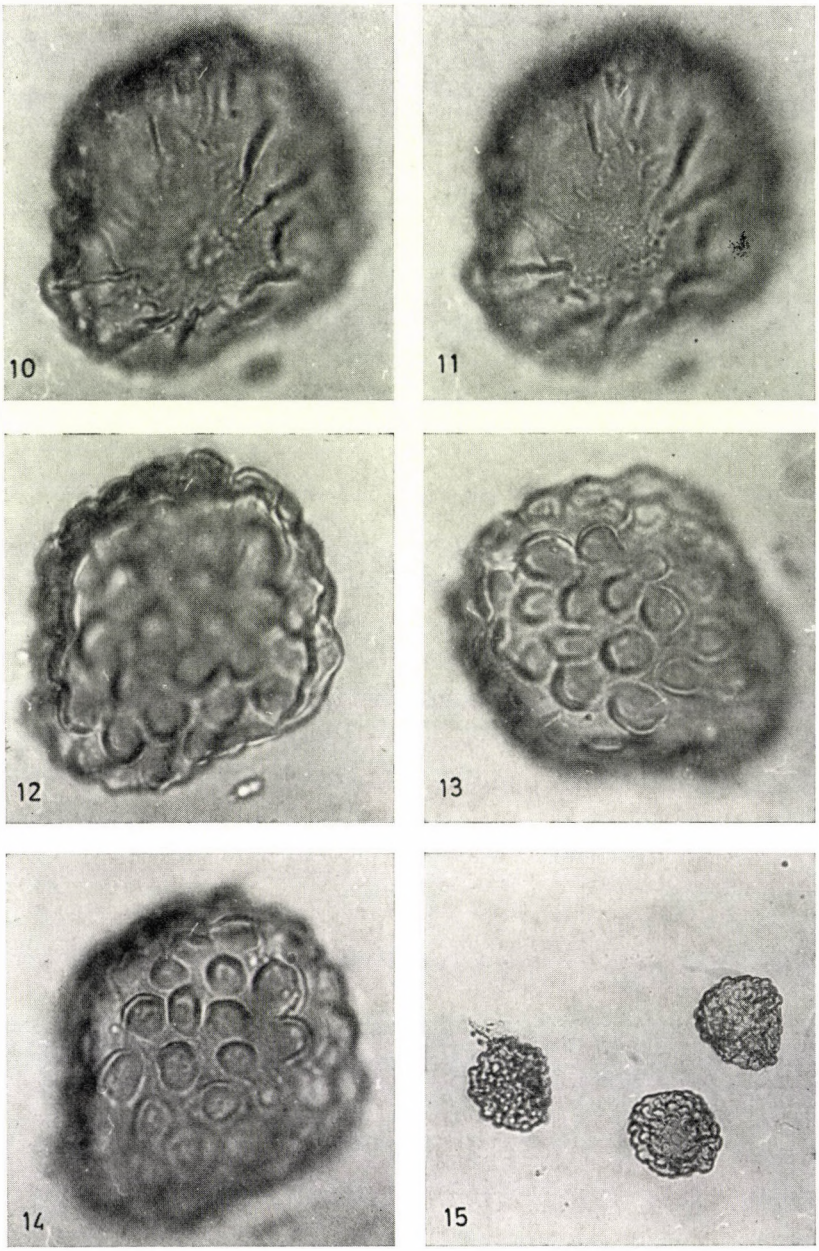


Figs 6—7

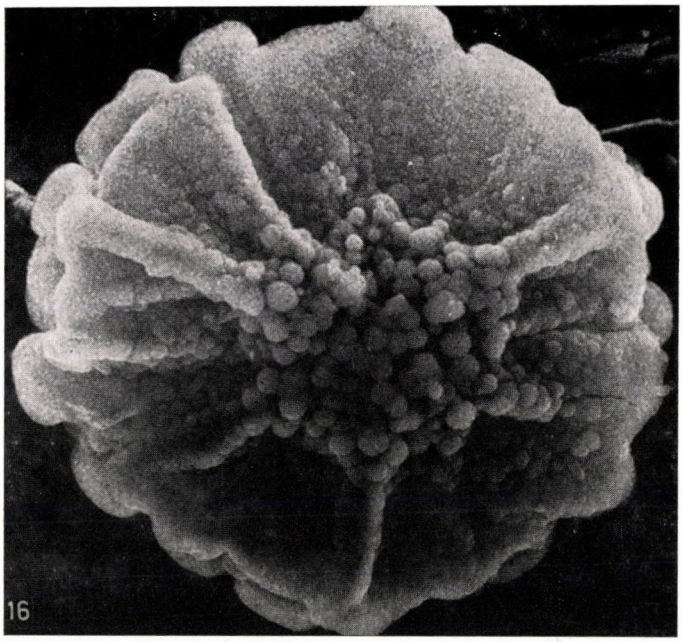


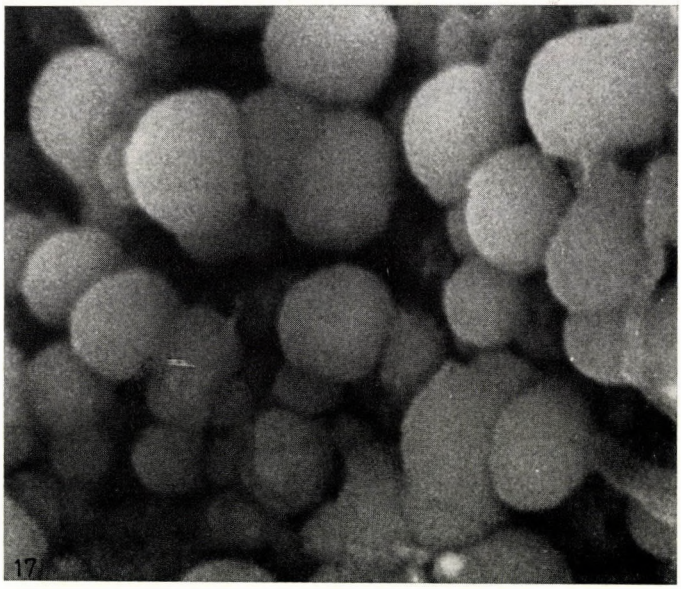


Figs 8—9



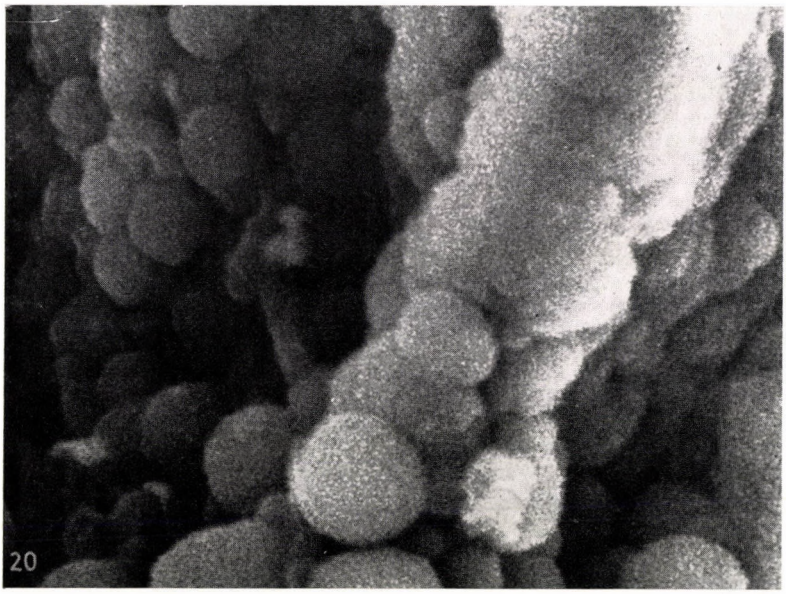
Figs 10—23. Encalypta rhabdocarpa Schwaegr. 10—11. Proximal face, *LMG* (×1000). 12—14. Distal face, *LMG* (×1000). 15. Group (proximal and distal face), *LMG* (×250). 16. Proximal face, *SEMG* (×2000). 17. Proximal face, central spheroids, *SEMG* (×10 000). 18. Proximal face, central spheroids, a part of aperture, *SEMG* (×6000). 19. Proximal face, central spheroids and nanogranules, *SEMG* (×10 000). 20. Proximal face, a wrinkle joining with the central spheroids, *SEMG* (×6000). 21. Proximal face, central part of wrinkles, *SEMG* (×10 000). 22. Distal face, *SEMG* (×2000). 23. Details of ornamentation in distal face, *SEMG* (×10 000)





Figs 16—17

Figs 18—19



Figs 20—21

Figs 22 – 23

Spore morphology:

Size: Mean value 48 μm, size range 50—46 μm.

Shape and structure: Spore spheroidal but on the proximal face flattened. Cryptotrilete. Sclerine of the distal face is about 5—7 μm that of the proximal face is about 2—3 μm thick, processes included.

Ornamentation: There are distinct differences in ornamentation between the two faces of the spores. The distal face is regularly and densely covered with rather uniform hemispherical bubble-like elements severed by smooth interstices. These verrucae are largest (diameter about 7 μm) in the centre of the distal face and become smaller (4 μm) on approaching the edge of the distal face of spores. In SEM, in the centre of the proximal face densely spaced regularly shaped gemma-like spheroids are visible which are usually less than 1 μm in diameter. They cover a circular area (diameter about 4—5 μm) which is the supposed place of aperture where a trilete-mark can occasionally be seen. In the LM it usually looks like only a finely dotted circle. From this central place 5—7 indistinct (1—3 μm broad and high), irregularly situated wrinkle-like arms run to the edge of the proximal face, radially (some of them parallel) and coalesce with the terminal verrucae of the distal face.

Locality: Sör-Tröndelag, Kongsvoll, near river Driva (Norway); P. Olsson, 1883/*101599*.

Encalypta brevicolla Bruch (Figs 24—41)

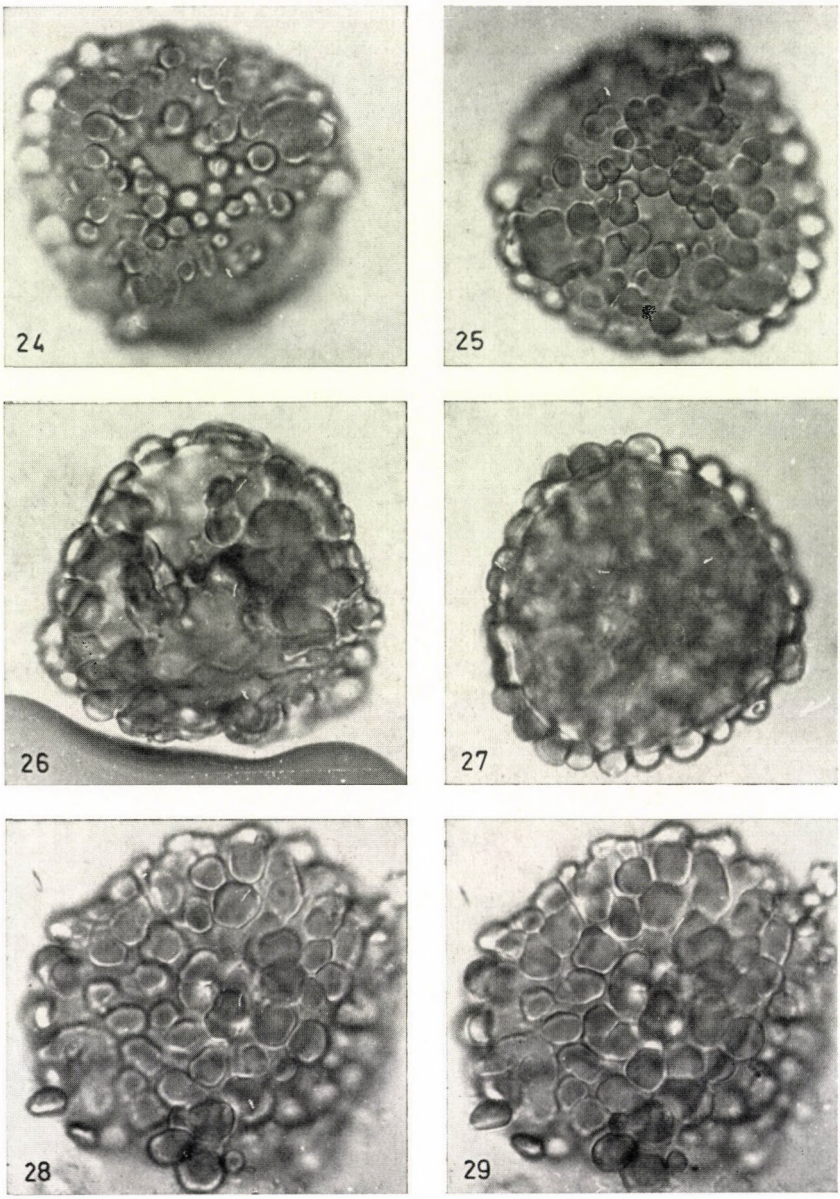
Synonyms: *E. longicolla* var. *brevicolla* B. S. G., *Leersia brevicolla* Lindb.
Area: Circumboreal, boreal-arctic, in subalpine region.
Ecology: Xerophyte, heliophilous, saxicolous, indifferent. On classic soils in clefts and on walls of rocks (rich or poor in lime).
Spore formation: Sporogonia are regularly developed. Fossil spores are not to be expected.
Cytotaxonomy: ?

Spore morphology:

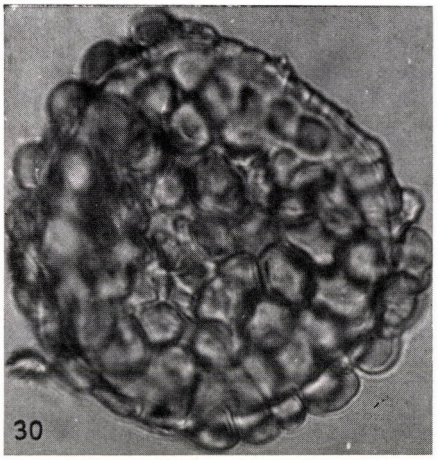
Size: Mean value 42 μm, size range 48—36 μm.

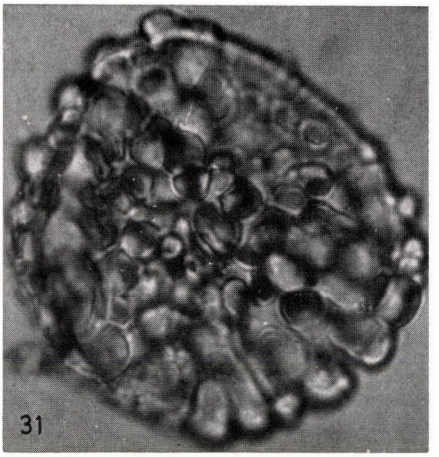
Shape and structure: Spores slightly triangular, somewhat flattened on the proximal face. Cryptotrilete. Exine is about 1—1.5 μm in thickness and with elements is about 6 μm thick in the distal and 2 μm in the proximal face.

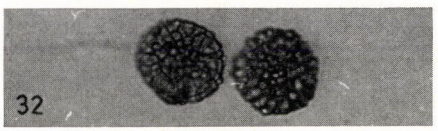
Ornamentation: There are distinct differences in ornamentation between the two faces of the spores. The distal face regularly and densely covered with elongate, not confluent occasionally tooth-like verrucae, which are about 4 μm in diameter and about 4—6 μm in length. The proximal face of spores hardly ornamented. The about

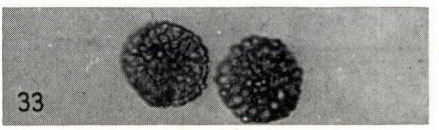


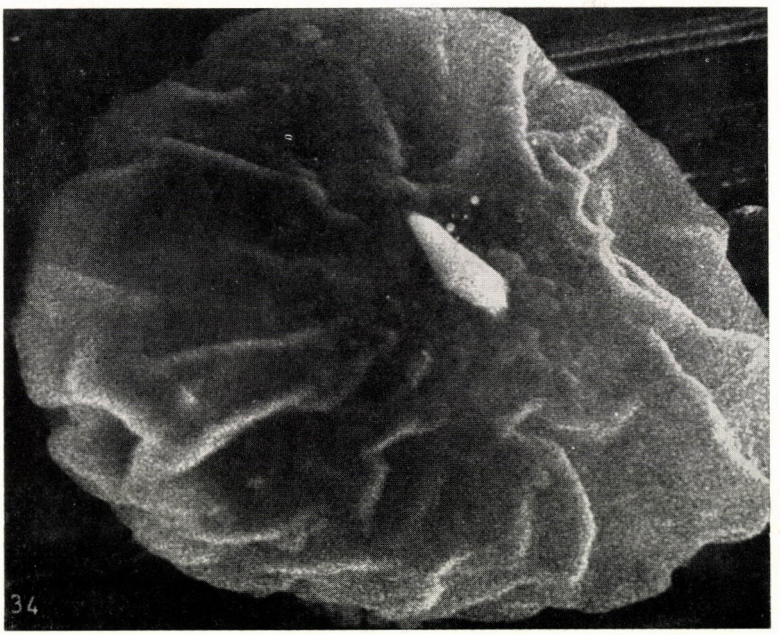
Figs 24—41. Encalypta brevicolla Bruch. 24—27. Proximal face, *LMG* (×1000). 28—29. Distal face, *LMG* (×1000). 30—31. Lateral view, *LMG* (×1250). 32—33. Distal face, *LMG* (×250). 34. Proximal face, *SEMG* (×2000). 35. Wrinkle joining with the terminal verrucae of the distal face, *SEMG* (×6000). 36. The central part of proximal face, *SEMG* (×10 000). 37. Proximal face, *SEMG* (×2000). 38. Central part of proximal face, *SEMG* (×3500). 39. Distal face, *SEMG* (×2000). 40. Distal face, *SEMG* (×2000). 41. Details of the distal face with tooth-like verrucae, *SEMG* (×6000)



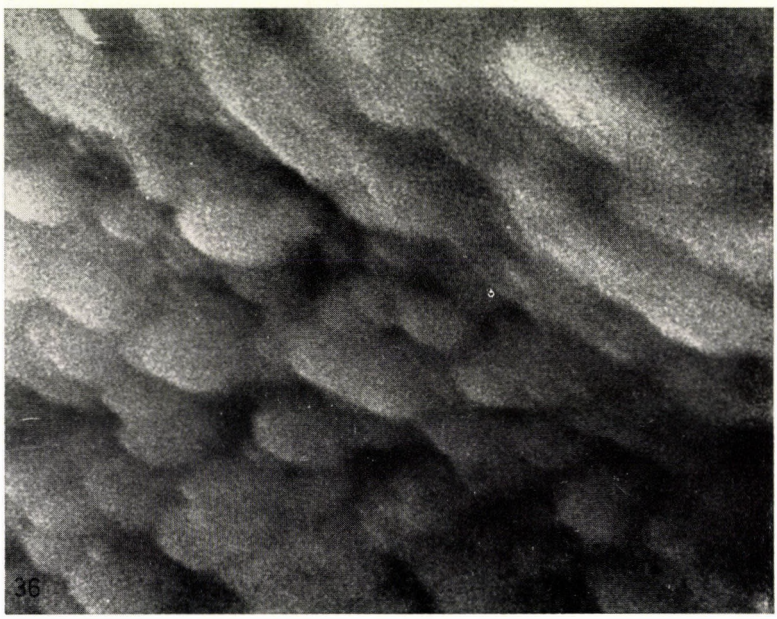




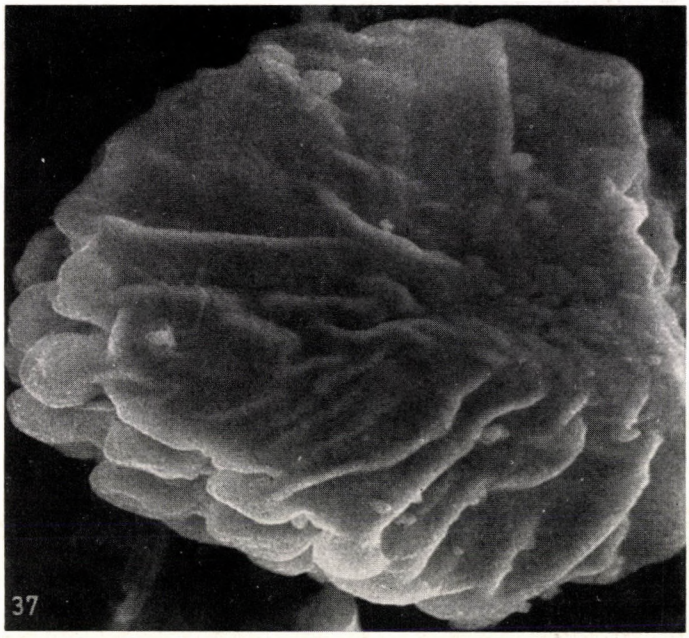


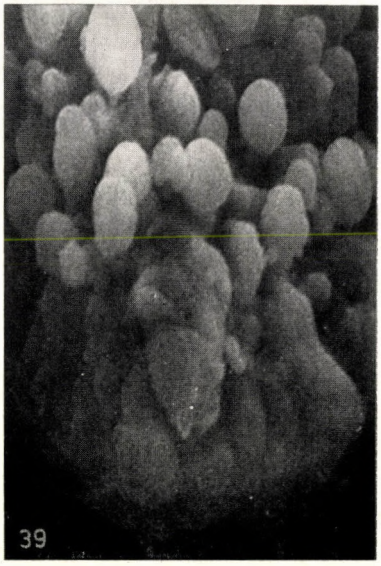


Figs 30 – 34

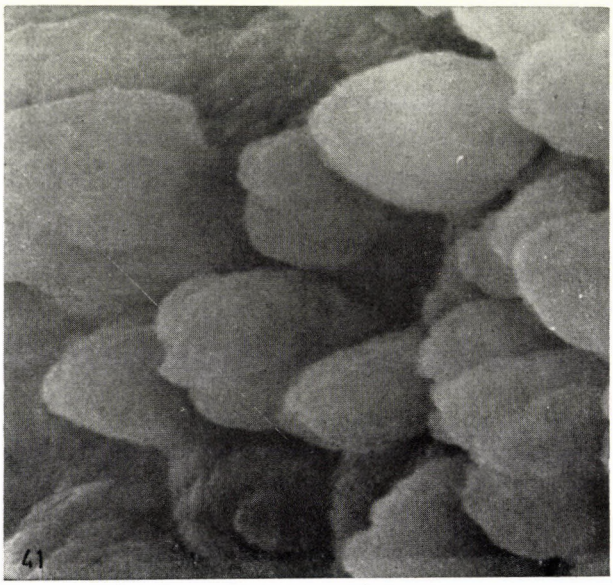


Figs 35—36





Figs 37—39



Figs 40—41

2 *μm* broad and high verrucae usually form a group only in the centre of proximal face. Elements here are crowded and somewhat confluent. Sometimes they are situated along a trilete mark, but more often they cover it.

Locality: Pohjois-Pohjanmaa, near Muhos. Leppiniemi (Finland); T. ULVINEN, 1966/*102284*.

Encalypta vulgaris Hedw. (Figs 42—55)

Synonym: *E. extinctoria* Lindb.
Area: Circumboreal, disjoint in Australia. Mostly on plains and mountains of medium height, rarely in alpine regions, too.
Ecology: Xerophyte, heliophilous, terri-saxicolous, calciphile. Mostly on limestone and calcareous soils, but also on debris of other kinds of rocks (dolomite, basalt, andesite), and on sediments (loess, loam, sand) containing lime.
Spore formation: Sporogonia are regularly developed. Fossil spores may hardly be expected.
Cytotaxonomy: Diploid, n = 26.

Spore morphology:

Size: Mean value 36 μm, size range 40—32 μm.

Shape and structure: Spores spheroidal, flattened on the proximal face. Cryptotrilete. Exine is about 1—1.5 μm thick and with elements about 7 μm thick in the distal and 2—3 μm in the proximal face.

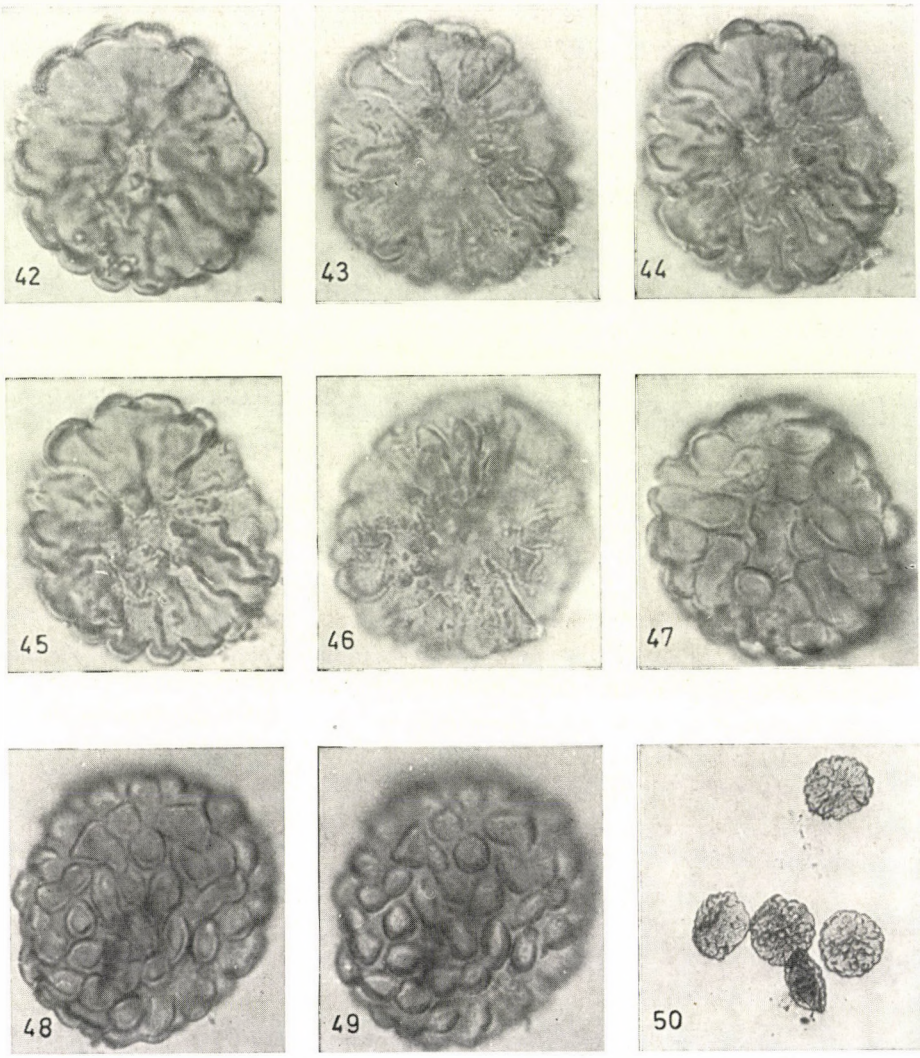
Ornamentation: There are distinct differences in ornamentation between the two faces of the spores. The distal face is regularly and densely covered with rather uniform, elongate verrucae. Their diameter is about 4 μm, length 5—6 μm. Verrucae become gradually smaller proceeding from the centre of the distal face toward the proximal face. Under ×10,000 magnification, in SEM the surface of these verrucae is not smooth. They are densely granulated with nanogranules.

The centre of the proximal face is covered by small (1—1.5 μm in diameter) spheroids separated from each other. These cover the place of aperture. Around them some bigger (4—5 μm) verrucae similar to those of distal face are usually scattered. From this central place, 15—20, hardly 2 μm wide and high wrinkles are running to the edge of the spore and joining there the marginal verrucae of the distal face.

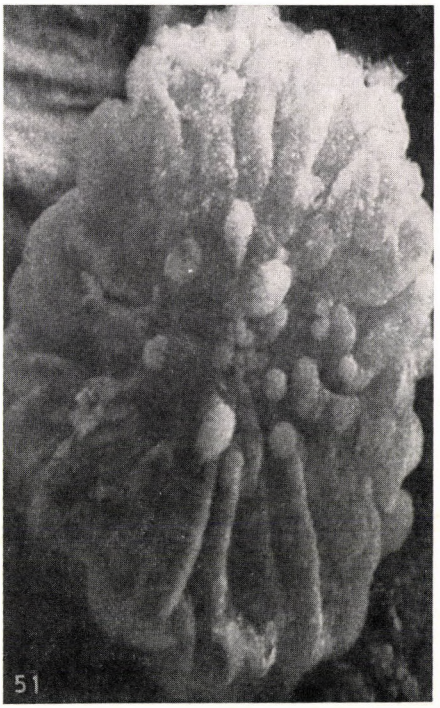
Locality: The North Borsod Karst, near Aggtelek, on the Mt. Baradlatető (Hungary); Á. BOROS, 1928/*101780*.

Encalypta affinis (Hedw.) fil. Web. et Mohr (Figs 56—67)

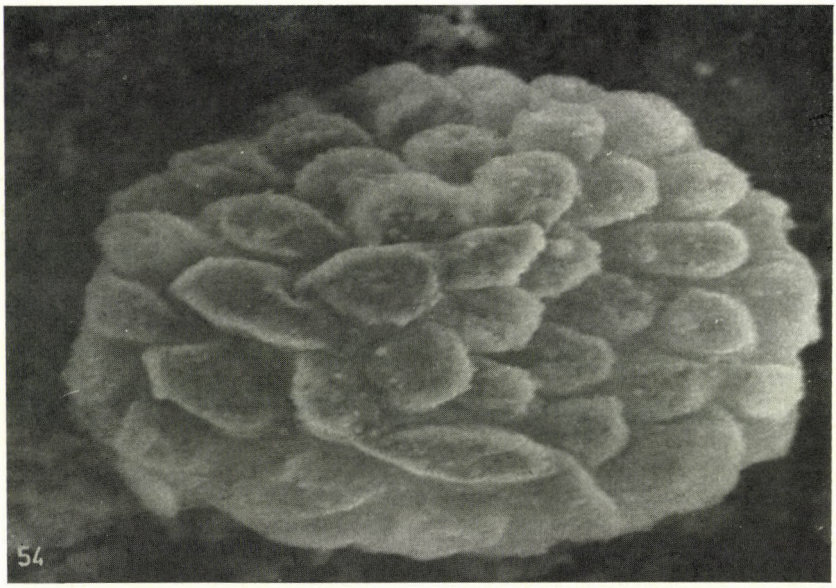
Synonyms: *E. apophysata* Nees et Hornsch., *Leersia affinis* Lindb.
Area: Circumboreal, alpine.

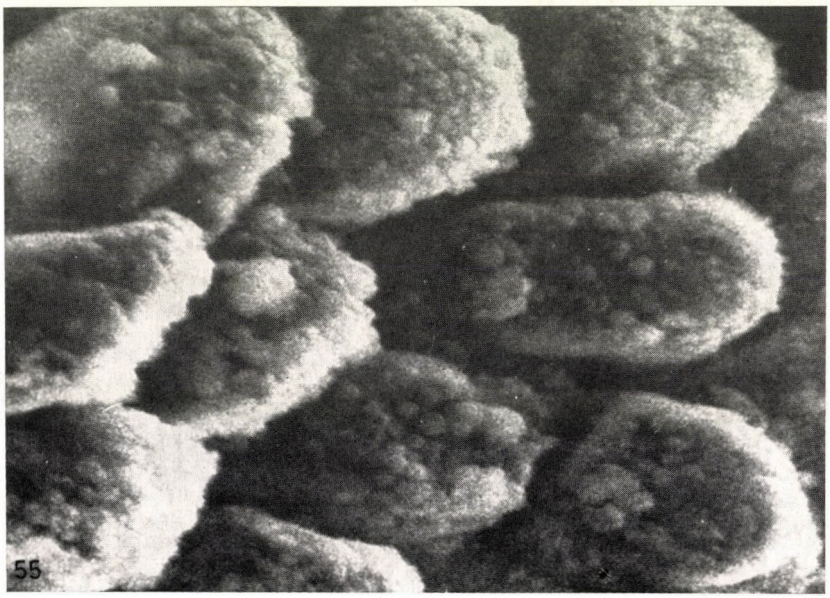


Figs 42—55. Encalypta vulgaris Hedw. 42—46. Proximal face, *LMG* (×1000). 47—49. Distal face, *LMG* (×1000). 50. Group (proximal and distal face), *LMG* (×250). 51—52. Proximal face with small spheroids and large verrucae in the central part, *SEMG* (×2000). 53. Central part of proximal face, *SEMG* (×6000). 54. Distal face, *SEMG* (×2000). 55. Details of distal face with elongate verrucae covered by nanogranules, *SEMG* (×6000)

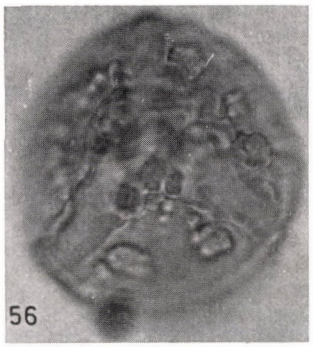


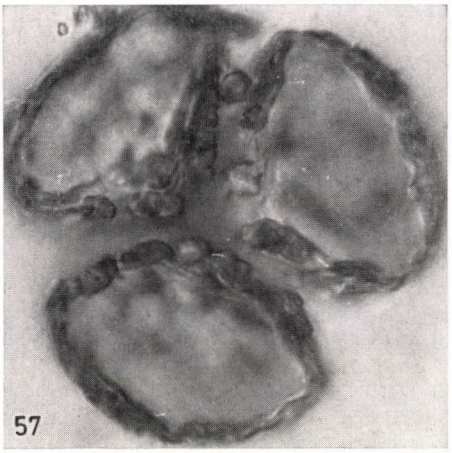
Figs 51—53

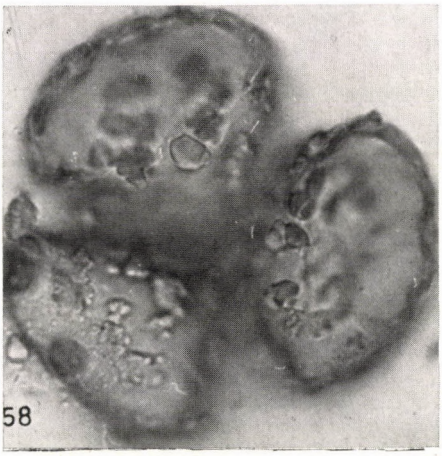


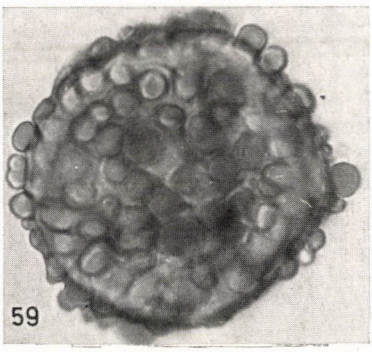


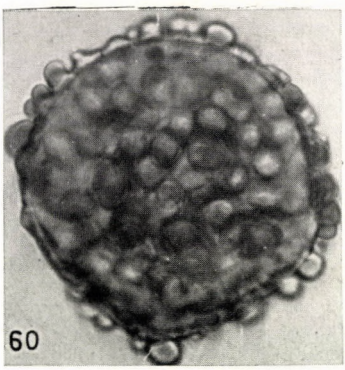
Figs 54—55

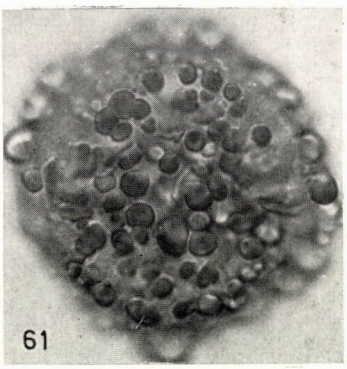


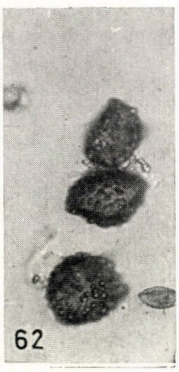




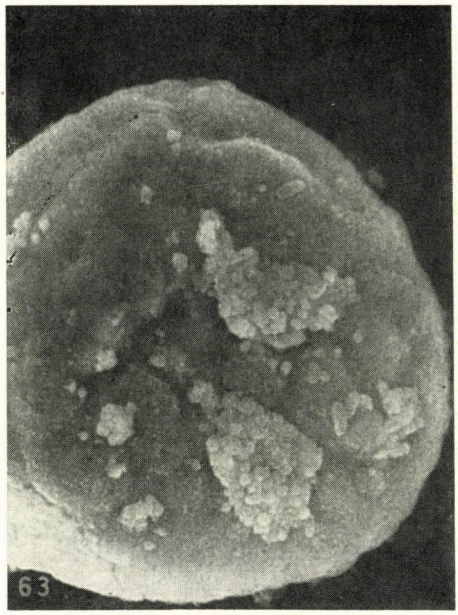


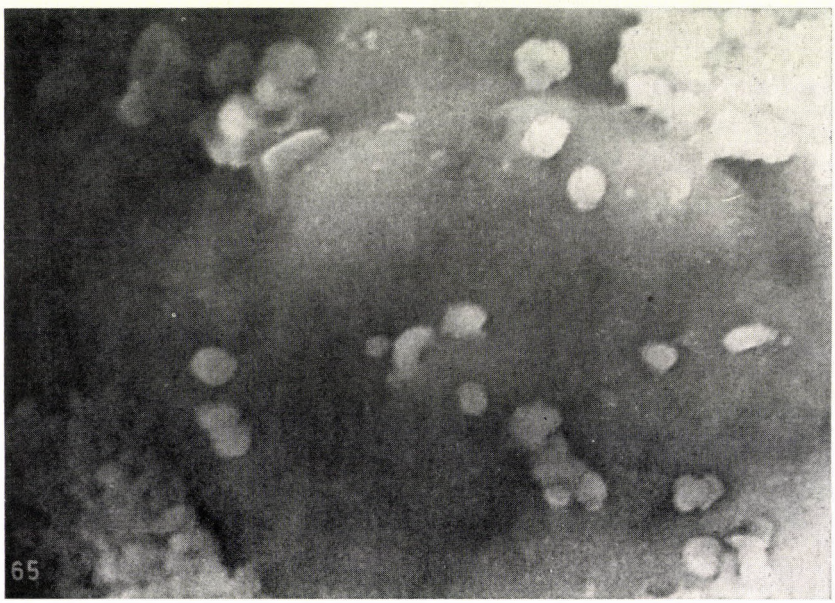




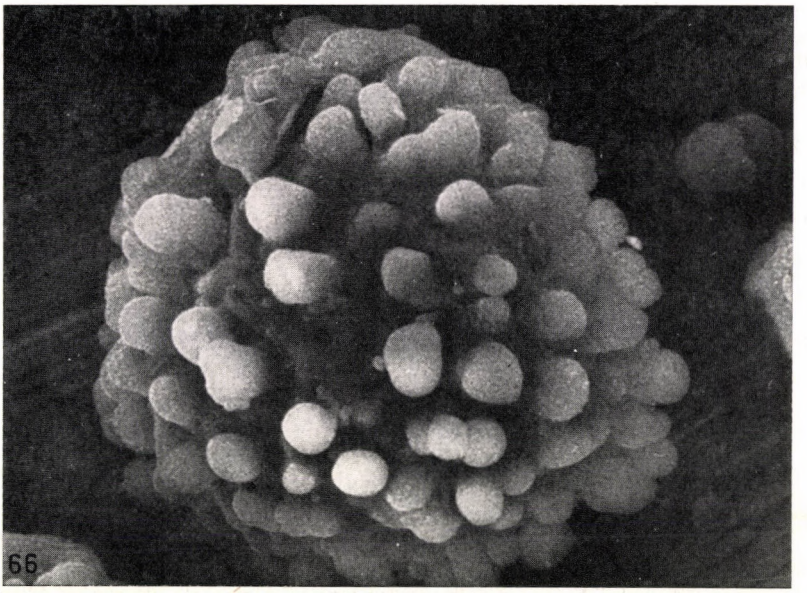


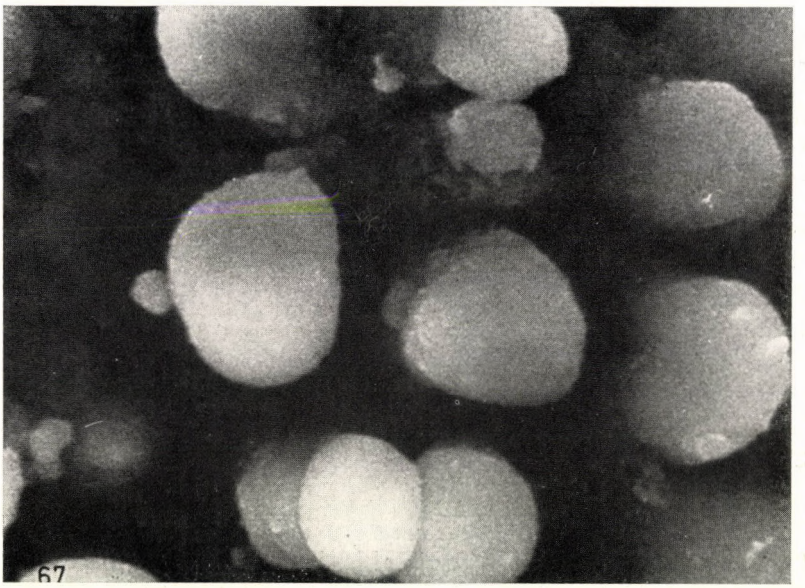
Figs 56—67. Encalypta affinis (Hedw.) fil. Web. et Mohr. 56. Proximal face, *LMG* (×1000). 57—58. Spore tetrads showing the proximal faces of spores, *LMG* (×1000). 59—61. Distal face, *LMG* (×1000). 62. Group (proximal face and lateral view), *LMG* (×250). 63—64. Proximal face, with irregularly arranged groups of confluent verrucae, *SEMG* (×2000). 65. Details of proximal face, *SEMG* (×6000). 66. Distal face, *SEMG* (×2000). 67. Details of distal face, *SEMG* (×6000)





Figs 63 – 65





Figs 66—67

Ecology: Mesophyte, helio-sciophilous, saxicolous, indifferent. On humous rocks and in clefts of rocks (rich or poor in lime).
Spore formation: Sporogonia are regularly developed. Fossil spores are hardly to be expected.
Cytotaxonomy: Diploid, n = 13.

Spore morphology:

Size: Mean value 38 μm, size range 40—32 μm.

Shape and structure: Spores subtriangular, more or less flattened on the proximal face. Cryptotrilete. Exine in the distal face is about 5 μm in thickness and about 2 μm thick in the proximal face with processes.

Ornamentation: There are differences in ornamentation between the two faces of the spores. Exine of the distal face consists of verrucae, more or less angular in their cross section and irregular in shape, size (1—4 μm in diameter) and arrangement. The surface of verrucae usually smooth. The proximal face of spores are hardly and very unevenly ornamented. The surface of this face is smooth, and verrucae form only a few irregularly arranged groups. Elements here are usually confluent and more irregular both in shape and size than in the distal face. In the centre of the proximal face from time to time a trilete mark is visible.

Locality: Lule Lappmark, Kvikkjokk (Sweden); HJ. MÖLLER, 1923/*102292*.

Encalypta longicolla Bruch (Figs 68—91)

Area: Circumboreal, arctic-alpine. Mostly in alpine zone, but in arctic region in lower zones, too.
Ecology: Xero-mesophyte, heliophilous, saxicolous, calciphile. On limestone covered with humous soils.
Spore formation: Sporogonia are regularly developed. Fossil spores are hardly to be expected.
Cytotaxonomy: ?

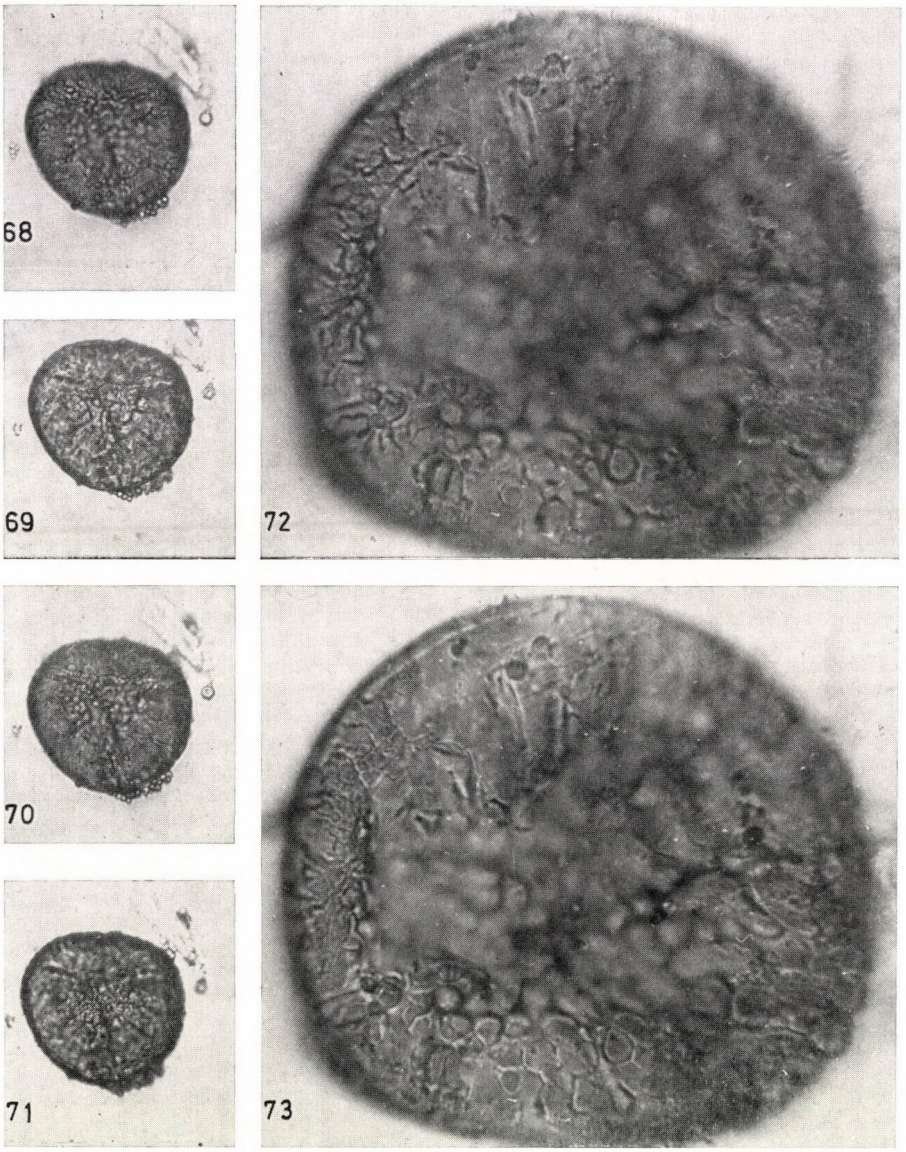
Spore morphology:

Size: Mean value 80 μm, size range 88—64 μm.

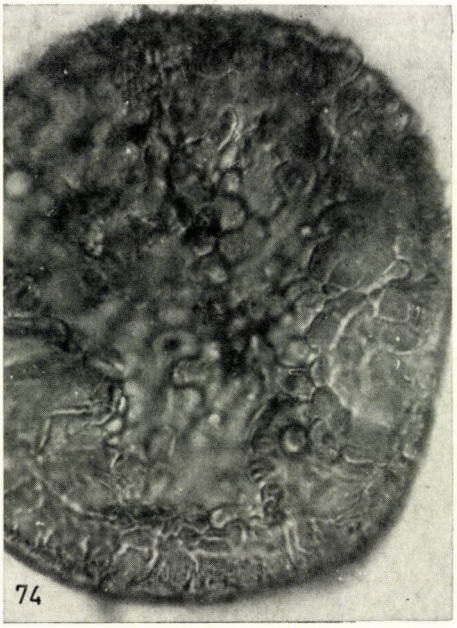
Shape and structure: Spores spheroidal, cryptotrilete. Exine in the distal face is about 4 μm thick and in the proximal face about 2—3 μm, processes included.

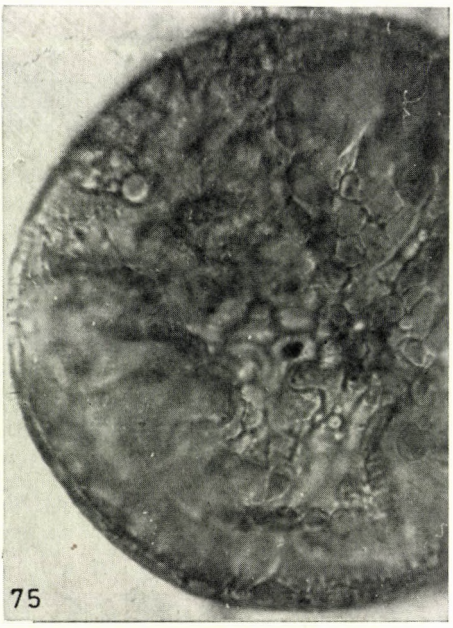
Ornamentation: There are noticeable differences in ornamentation between the two faces of spores. Exine in the distal face consists of big flat and entirely confluent verrucae which exhibit an irregularly cracked surface with angular meshes in different optical cross sections.

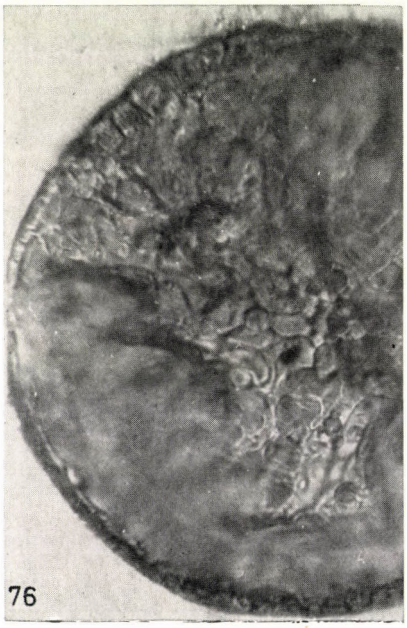
In the centre of the proximal face the ornamentation consists of verrucae similar to those of the distal face but these are larger and less confluent. These elements become more and more flat-

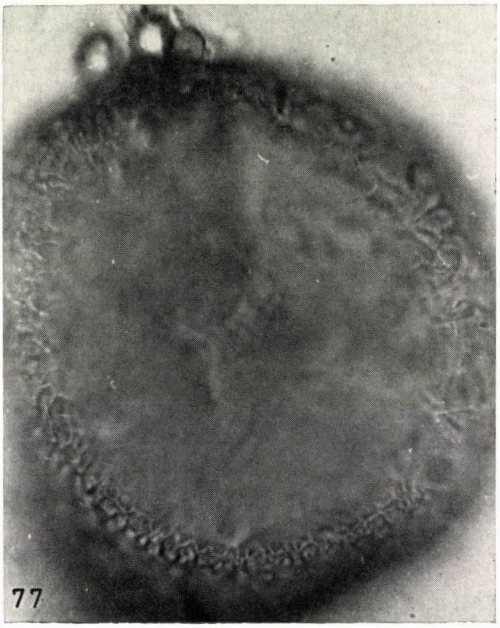


Figs 68—91. Encalypta longicolla Bruch. 68—71. Series of optical cross sections, *LMG* (×250). 72—73. Proximal face, *LMG* (×1000). 74—77. Proximal face (optical cross sections), *LMG* (×1000). 78—80. Proximal face, *LMG* (×1000). 81. Distal face, *LMG* (×1000). 82—84. Distal face. Irregularly cracked pattern of certain optical sections, *LMG* (×1000). 85. Distal and proximal face, *SEMG* (×400). 86. Proximal face, *SEMG* (×1000). 87. Central part of proximal face with aperture, *SEMG* (×3000). 88. Central verrucae in proximal face, *SEMG* (×6000). 89. Marginal part of proximal face with flattened, confluent elements, *SEMG* (×3000). 90. Details of distal face with large, flat, entirely confluent verrucae, *SEMG* (×6000). 91. Distal face, *SEMG* (×1000)

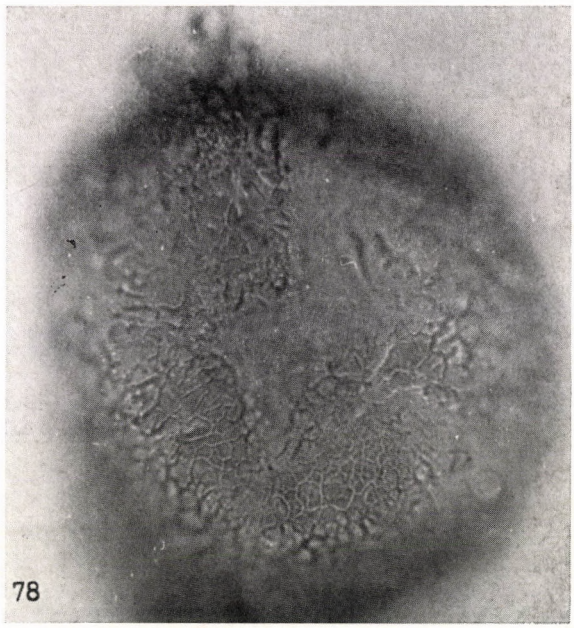


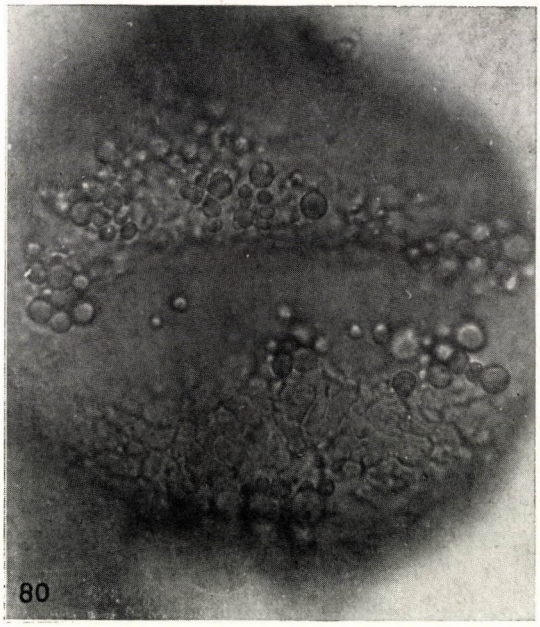


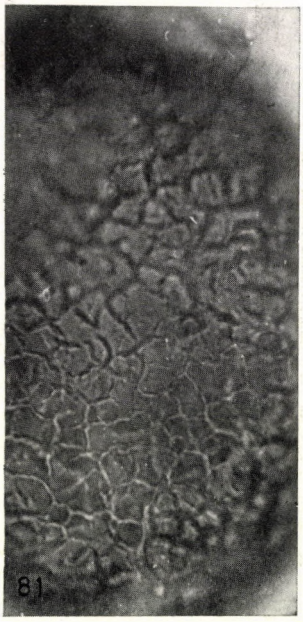




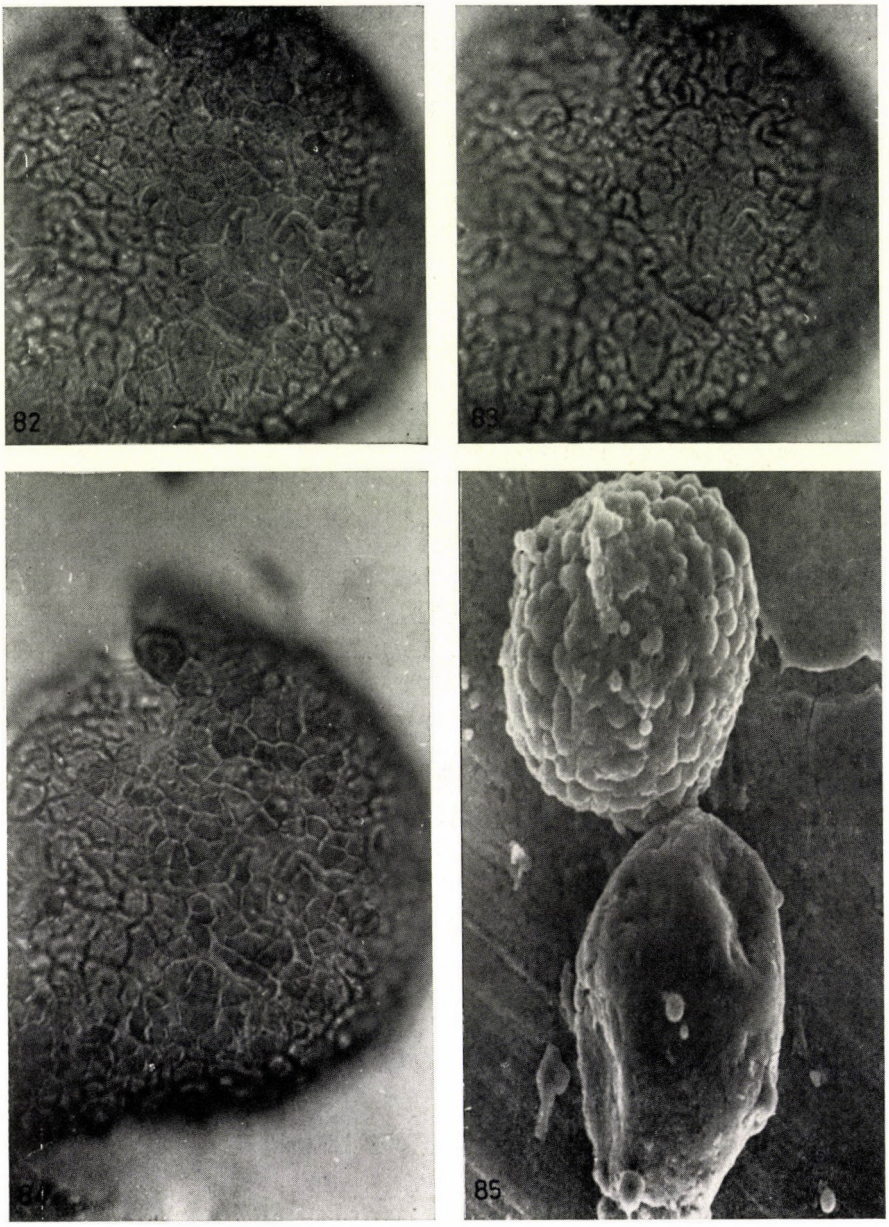
Figs 74—77



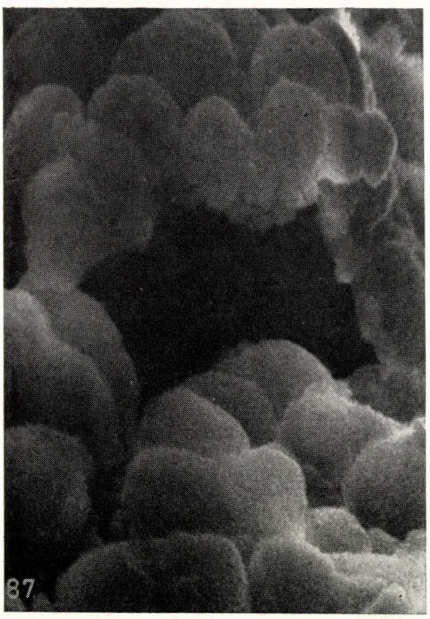


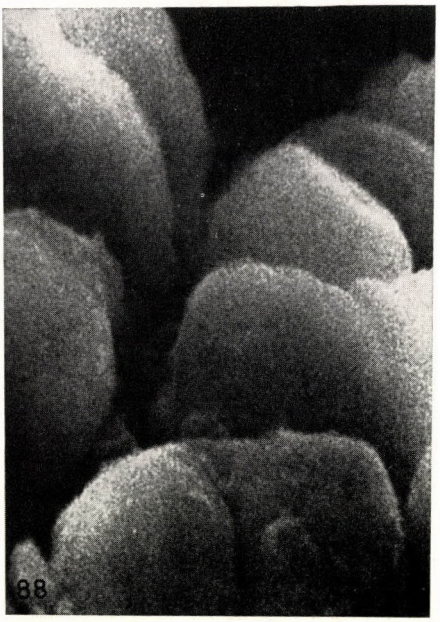


Figs 78–81

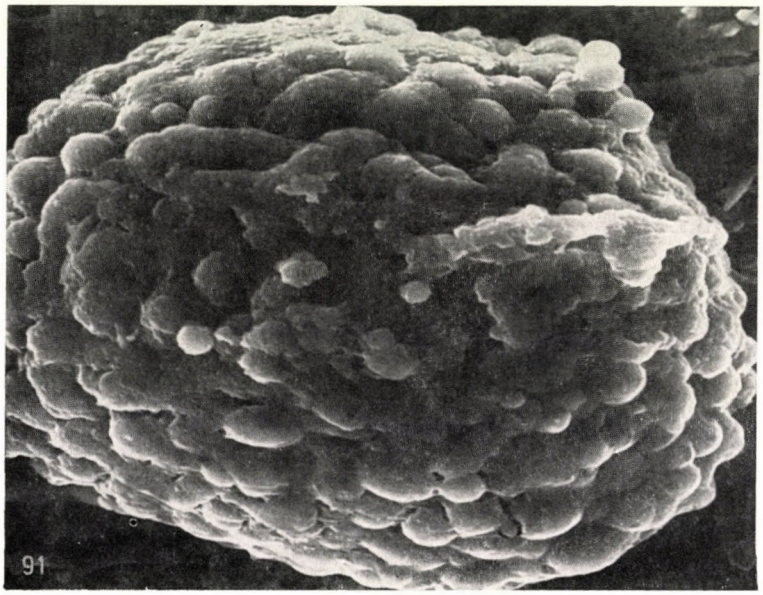


Figs 82—85





Figs 86—88



Figs 89—91

tened approaching the edge of proximal face and finally exhibit a coalescent, irregularly cracked surface. Among the central verrucae, sometimes an irregularly shaped opening of aperture can be seen.

Locality: The Bavarian foreland of Alps, on the Mt. Kirchstein (Germany); TH. HERZOG, 1920/*102286*.

Encalypta alpina Smith (Figs 92—103)

Synonyms: *E. commutata* Nees et Hornsch., *E. caucasica* Rupr., *Leersia alpina* Lindb.
Area: Circumboreal. In Europe and in North America in alpine zone, but in the arctic region in lower zones, too.
Ecology: Mesophyte, saxi-humicolous, heliophilous, calciphile. On humus, in the clefts of calcareous rocks, on limy stones in bogs, in arctic mires.
Spore formation: Sporogonia are regularly developed, fossil spores may be expected in peaty deposits of bogs.
Cytotaxonomy: Diploid, n = 14.

Spore morphology:

Size: Mean value 32 μm, size range 28—36 μm.

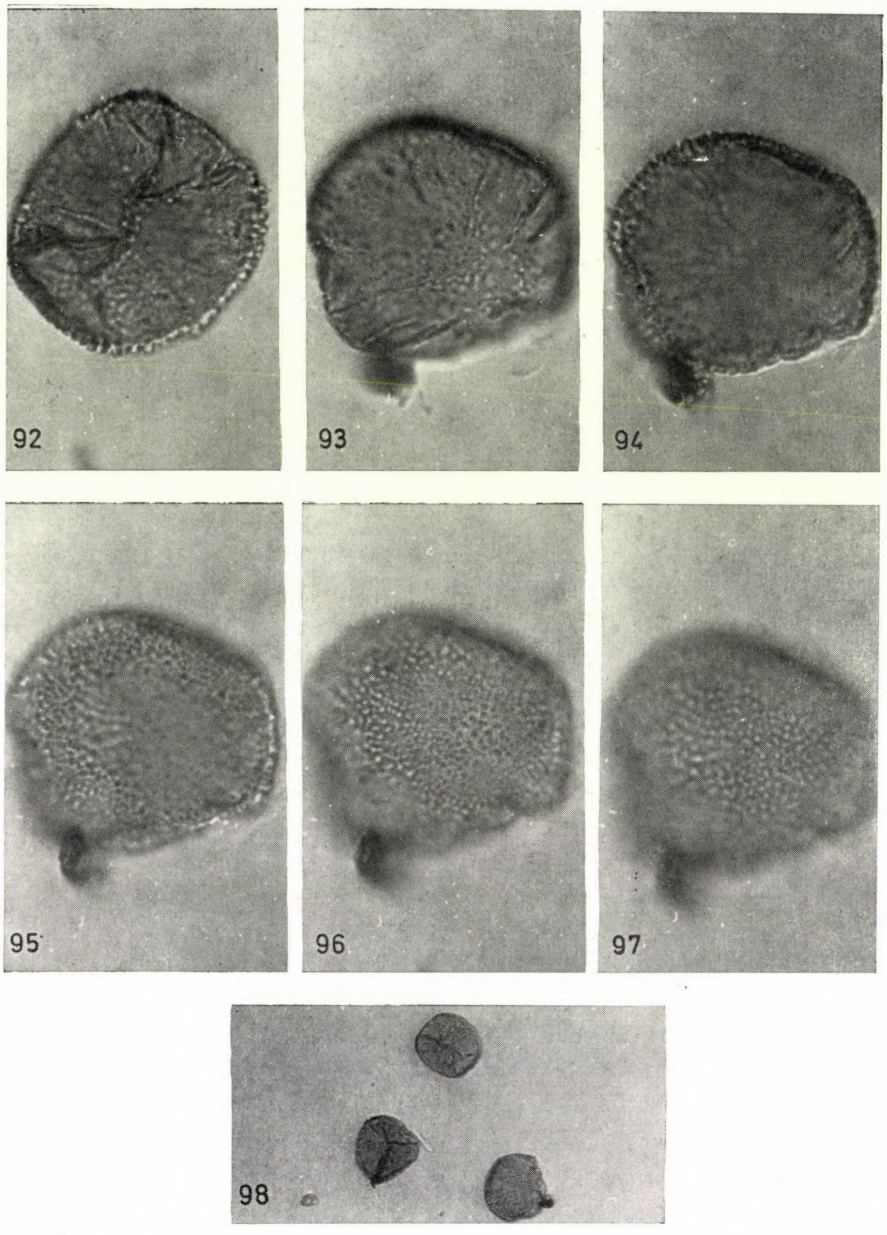
Shape and structure: Spores spheroidal-subtriangular. Katalept. Exine is about 2 μm thick.

Ornamentation: The two faces of the spores are somewhat different from each other but owing to the delicate ornamentation and concealed aperture this difference is indistinct in LM. Exine consists of small (about 1 μm in diameter) angular granules composed of nanogranules and varying both in size and shape. In the distal face elements evenly and densely spaced, several of them occasionally tightly attached to each other. In the proximal face elements are similar — both in size and shape — to those of the distal face, but irregularly and gradually less spaced. In the centre of the proximal face elements are densely spaced, but in the distal face they are isolated from each other. Among them an irregularly shaped opening can occasionally be seen. A few (3—5) short, very indistinct wrinkle-like arms are radially running from the centre to the edge of proximal face.

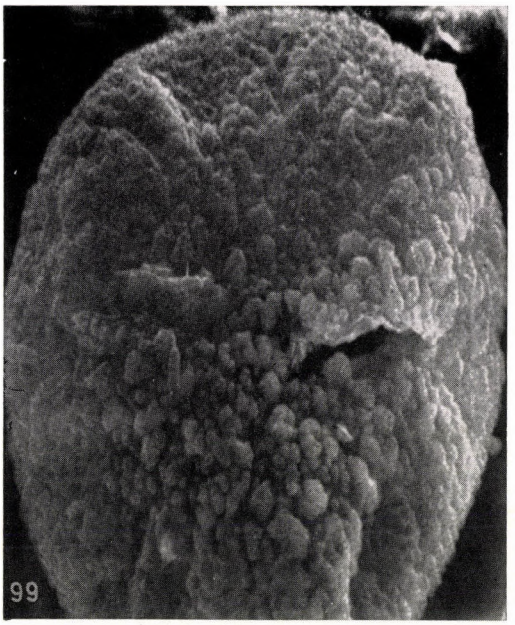
Locality: The Tatra Mts., on the Mt. Zadnie Jatky (Czechoslovakia); Á. BOROS, 1958/*101601*.

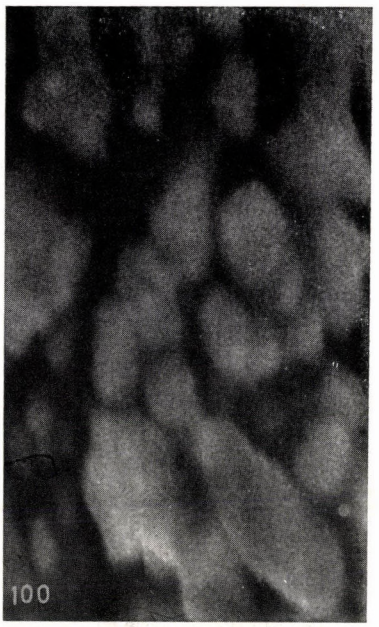
Encalypta procera Lindb. (Figs 104—111)

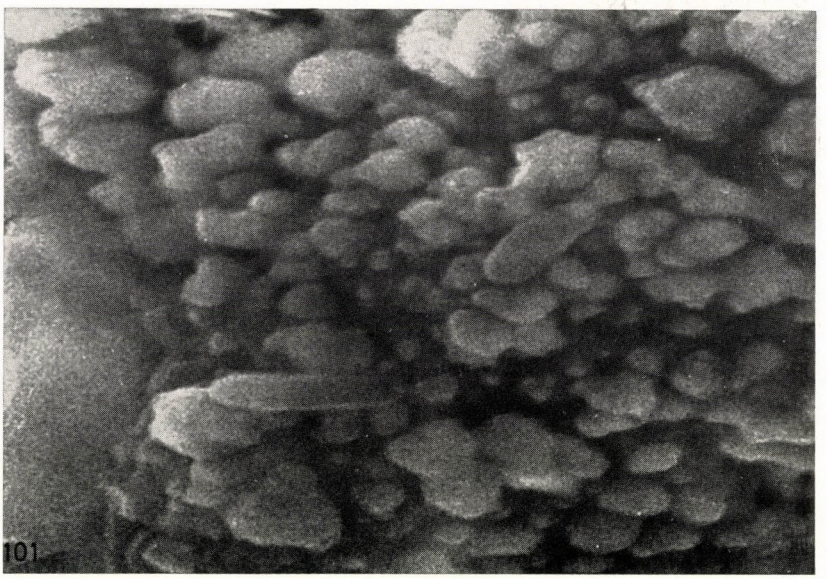
Area: Circumboreal, boreal-arctic.
Ecology: Mesophyte, heliophilous, terri-saxicolous, calciphile. On limestone and calciferous rocks, on wet, humous habitats, too. On the rocks in alpine meadows and mountain tundras.
Spore formation: Sporogonia are developed. Fossil spores may be expected in sediments of alpine meadows and wet tundras.
Cytotaxonomy: Diploid, n = 27.



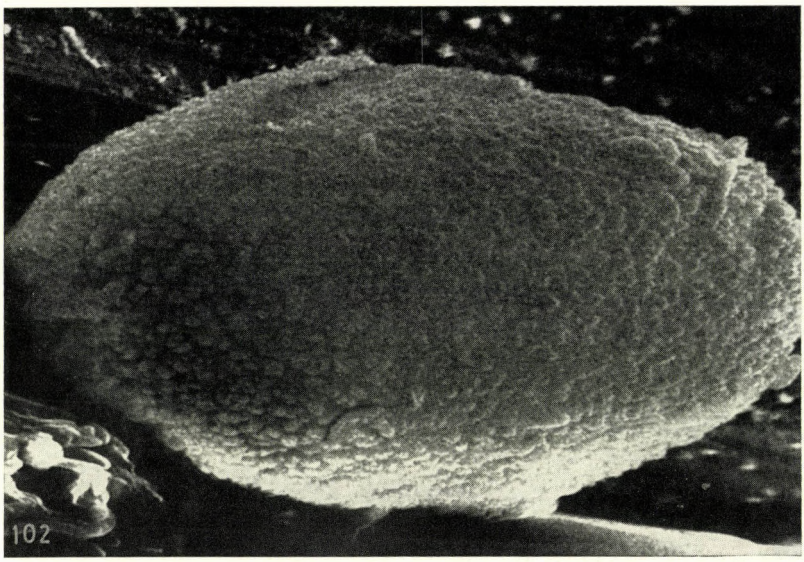
Figs 92—103. Encalypta alpina Smith. 92—94. Proximal face, *LMG* (×1000). 95—97. Dista face, *LMG* (×1000). 98. Group, *LMG* (×250). 99. Proximal face, *SEMG* (×2000). 100. Verrucae of proximal face, *SEMG* (×10 000). 101. Verrucae of central part in proximal face, *SEMG* (×6000). 102. Distal face, *SEMG* (×2000). 103. Granules formed by clusters of nanogranules in distal face, *SEMG* (×6000)

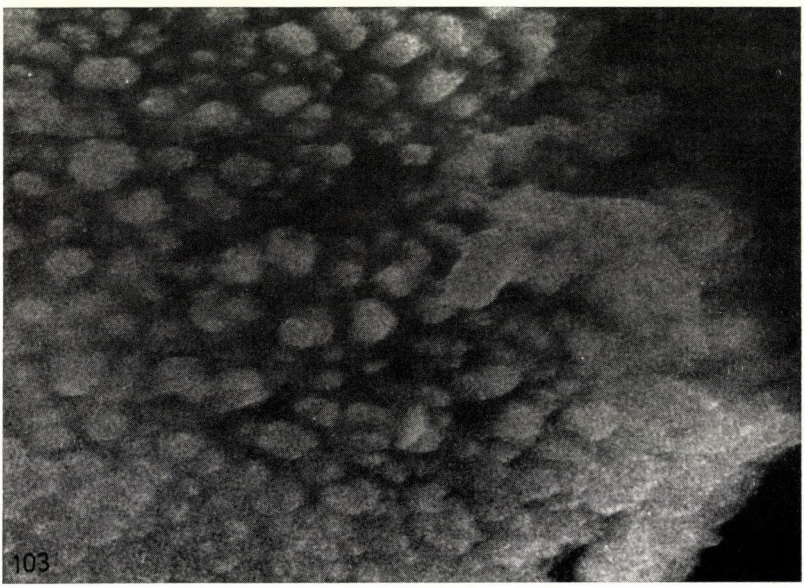




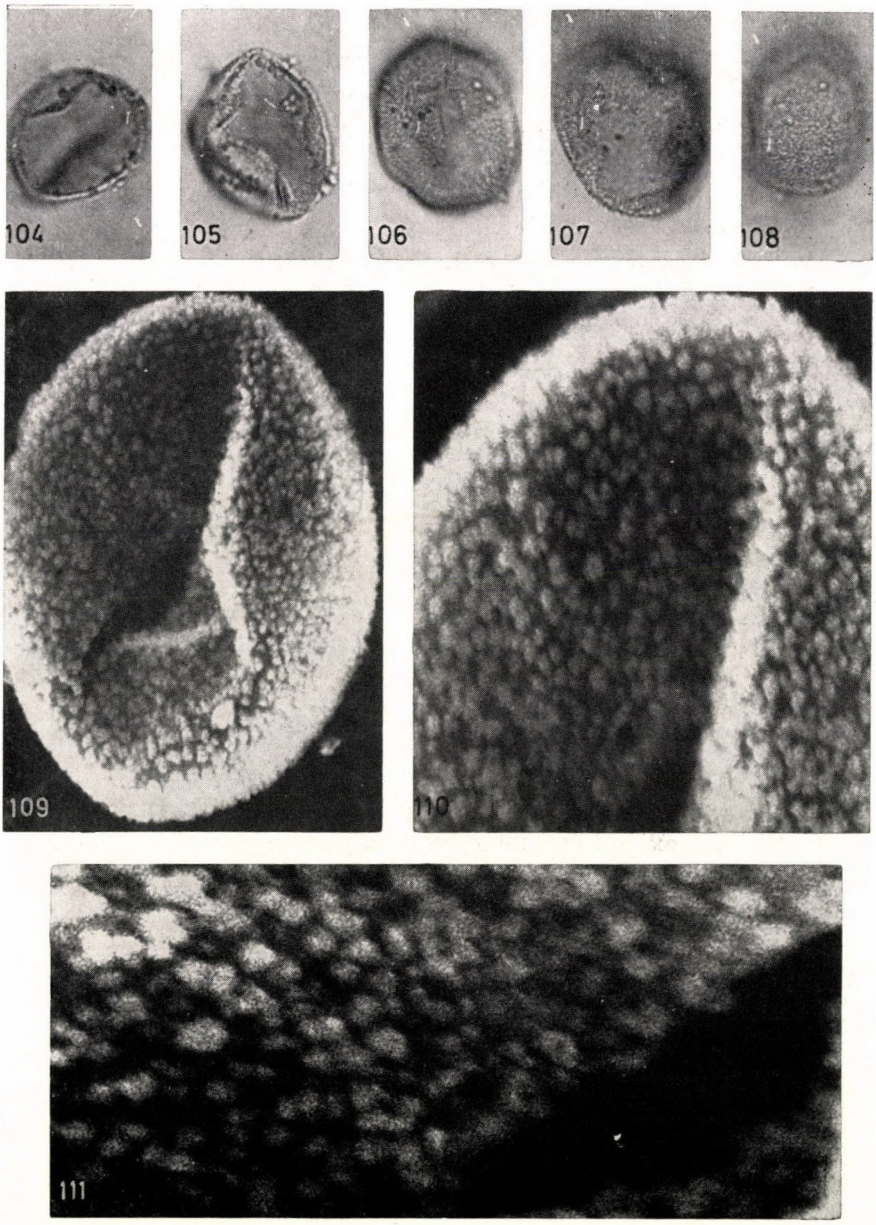


Figs 99—101





Figs 102—103



Figs 104—111. Encalypta procera Bruch. 104—108. Different optical cross sections. Overlaid gemmae can be seen, *LMG* (×1000). 109. Cf. proximal face, *SEMG* (×3000). 110—111. Details, showing the separate granules composed of nanogranules, *SEMG* (×6000; ×10 000)

Spore morphology:

Size: Mean value 20 μm, size range 24—18 μm.

Shape and structure: Spores spheroidal, after acetolyzes often wrinkled, collapsed. Katalept. In the centre of cf. proximal face a thinner-walled "leptoma" like area suggests the place of an aperture. Probably owing to the somewhat thick exine (about 0.6—0.8 μm) — thicker than that of *E. streptocarpa* — it is rarely opened.

Ornamentation: Sexine shows a delicate, regularly arranged, densely granulated pattern, similar in both faces of the spore. Elements are small, irregularly shaped, separate granules, composed of nanogranules. These processes are occasionally overlaid with scattered, about twice or three times larger (0.6—1.0 μm) spheroidal gemmae which are loosely attached to the surface.

Locality: Near Svatsum (Norway); E. RYAN, 1892/*32852*.

Encalypta streptocarpa Hedw. (Figs 112—121)

Synonyms: *E. contorta* Lindb., *Leersia contorta* Lindb.
Area: Circumboreal.
Ecology: Xerophyte, heliophilous, terri-saxicolous, calciphile. On limestone and on calciferous rocks and soils, on open and half-shaded habitats.
Spore formation: Sporogonia are developed. Fossil spores are not to be expected.
Cytotaxonomy: ?

Spore morphology:

Size: Mean value 12 μm, size range 13—7 μm.

Shape and structure: Spores spheroidal slightly plane-convex. Due to the thin exine (about 0.5 μm thick), after preparation often rumpled, collapsed. Katalept. In the centre of plane face there is a thinner-walled leptomalike area or sometimes a triangular or circular opening.

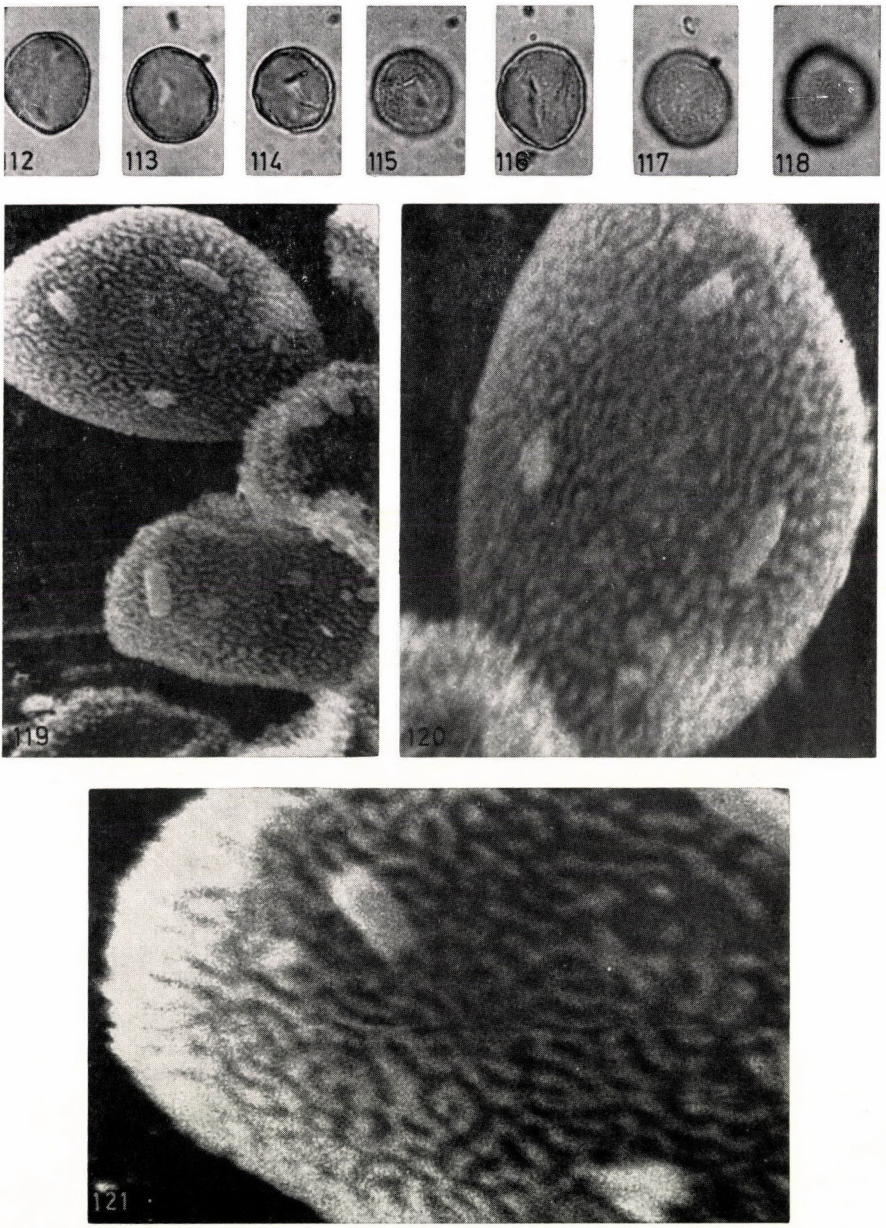
Ornamentation: In LM, even at $\times 1000$ magnification sexine shows only a very delicate dotted pattern due to the minute granules, similar in both faces. Granules are somewhat angular in cross sections probably composed of nanogranules. In SEM it can be seen that some (3—5) granules occasionally coalesce into small, more or less regularly winding rows showing a fingerprint-like pattern.

Locality: The Tatra Mts., near Hrabusice (Czechoslovakia); Á. BOROS, 1958/*102146*.

Conclusions

On the basis of spore morphology the examined spores of the *Encalypta* genus can be divided into three types.

The first spore type comprises the *E. ciliata*, which seems to be well separated from every other species by the very characteristic morphology in



Figs 112—121. Encalypta streptocarpa Hedw. 112—118. Different optical sections, *LMG* (×1000). 119. Fingerprint-like pattern, *SEMG* (×3000). 120. The same, *SEMG* (×6000). 121. The same, *SEMG* (×10 000)

both fac of its spores as the central brochus, the well-developed murus-like arms, the marginal meshes and the trilete mark which is most of all developed here.

The second spore type comprises the *E. rhabdocarpa*, *E. vulgaris*, *E. brevicolla*, *E. affinis*, *E. longicolla* mainly based on the similarities in their ornamentation and cryptotrilete aperture. The ornamentation in the distal face of all the five species is composed of the same elements and has similar features. The structure and the ornamentation of the proximal face exhibit the same type in the case of *E. rhabdocarpa*, *E. brevicolla*, *E. vulgaris* and *E. longicolla;* namely, all of them have a central aperture covered with verrucae from where wrinkle-like arms radially run to the edge of the proximal face and coalesce with the terminal verrucae of the distal face. Only *E. affinis* differs from this group in the ornamentation of its proximal face: it has no wrinkles and central verrucae at all, on its smooth surface the more or less confluent verrucae form only a few irregularly arranged groups. On the contrary of the similarities mentioned above the species within this group can well be separated to some extent. Thus, *E. rhabdocarpa* has well-separated, regularly shaped, gemma-like, smooth spheroids in the centre of the proximal face. In the distal face spheroidal or hemispheroidal bubble-like, separated verrucae can be seen. *E. brevicollis* has more or less coalescent verrucae with smooth surface in the centre of the proximal face. Verrucae of its distal face are elongate, not confluent, occasionally tooth-like. In the centre of the proximal face of *E. vulgaris* there are large, not confluent, elongate verrucae beside the small spheroidal ones. Verrucae of the distal face are elongate and separate. In both faces verrucae are not smooth but covered with nanogranules. *E. longicolla* has more or less confluent verrucae in the central part of the proximal face and differs from the other species of this group in the very undistinct wrinkles. Verrucae of the distal face are flattened and entirely confluent which is characteristic only for this species. By its large size (80 μm) its spores differ from any other *Encalypta* species investigated so far.

The third spore type comprises *E. alpina*, *E. procera* and *E. streptocarpa*. All three have katalept spores ornamented by granules. None of them has distinct differences between the proximal and distal faces. In this group *E. alpina* is the transitional type — to some extent — between the second and third groups. Namely, this species has some differences between the two faces of its spore and the structure of its proximal face is similar to that of *E. longicolla*. Its spores and granules are essentially larger than those of *E. procera* and *E. streptocarpa*. The last two species, *E. procera* and *E. streptocarpa*. are similar to each other having no differences between the two faces of their spores. They differ, however, from each other as follows: *E. procera* has twice larger spore than *E. streptocarpa* and as a rule its granules do not coalesce forming fingerprint-like pattern which is characteristic for *E. streptocarpa*.

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CALORIC VALUES OF THE DOMINANT SPECIES IN AN OAK FOREST (QUERCETUM PETRAEAE-CERRIS) NEAR SÍKFŐKÚT, NORTH HUNGARY*

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This paper contains the caloric values of the dominant species in an oak forest (*Quercetum petraeae-cerris*) as well as the energy content of the phytomass of this ecosystem. Caloric values have been measured for several fractions of the same species and for various layers (trees, shrubs, herbs) of the stand. A decrease in caloric values can be observed moving from the trees to the herbs; values measured are 4657 (trees), 4476 (shrubs) and 4379 cal/g (herbs). There is no significant deviation between the caloric values of diverse species of the same layer but leaf and bark caloric values differ rather considerably depending on the species. On the contrary wood values constitute a more uniform range. The energy content of the dominant species is 113. 646×10^7 kcal/ha as calculated from the phytomass (in dry weight) and the caloric values.

An important direction of ecosystem research embraces the study of energetic relations, the quantitative description of energy flow and the judgement of ecological efficiency. Such research necessarily includes the determination of sample caloric values because so quantitative relationships can be expressed with a greater accuracy than if only dry weights are considered (GOLLEY, 1965; LIETH, 1968; RUNGE, 1971, 1973, etc.).

The ecosystem under study is a 65 years old climazonal oak forest (*Quercetum petraeae-cerris*) on brown forest soil situated in the southern part of the Bükk Mountains at an altitude of 300 m above sea level near the village Síkfőkút (JAKUCS, 1973) and investigated as "Síkfőkút Project" according to the "Man and Biosphere".

In the first part of our energy flow studies we determined the caloric values for several fractions of the dominant species as well as the energy content of the ecosystem's phytomass.

Methods

Caloric value measurements were carried out at three layers (trees, shrubs and herbs). The tree and shrub samples were collected between October 21 and 30, 1974. The samples of the two oak species were obtained from three felled trees, those of the shrubs from 5 felled individuals. The herbaceous samples were taken between May 26 and June 31, 1974 using both the monolithic and the individual sampling methods. The samples were dried at 85 °C, then ground, or comminuted and finally pelleted. Combustion heat of the samples was determined by an adiabatic bomb calorimeter in pure oxigen of 20 atm pressure. The calorimeter was calibrated with benzoic acid. Errors due to the ignition wire, the cotton thread and the cigarette paper into which the tablettes were packed were corrected. However, because of its low value, no consideration was given to the additional temperature increase due to the sulphuric and nitric acids evolving during combustion. At least three parallel measurements were made per sample type. The caloric values are given for dry and ash-free dry weight (LIETH, 1968; RUNGE, 1971; etc.). The ash content has been determined by heating at 500 °C while the temperature was increased stepwise.

* "Síkfőkút Project" No. 19.

Table 1a

Caloric value and ash content of oak species

(n = number of measurements, $s_{\bar{x}}$ = standard deviation of mean values)

	n	cal/g dry weight	$s_{\bar{x}}$	ash %	cal/g ash-free dry weight
Quercus petraea					
leaf, shade-adapted	5	4627	32.8	6.5	4947
light-adapted	5	4832	41.3	6.1	5144
twig ⌀ ≤ 1 cm	4	4646	47.2	3.7	4830
branch ⌀ 1—10 cm					
wood	3	4732	21.1	1.0	4789
bark	4	4264	30.3	9.0	4689
trunk					
wood	4	4747	19.9	0.5	4768
bark	4	4443	16.7	10.4	4959
root	3	4494	26.5	6.9	4829
fruit	3	4654	8.1	2.6	4780
Quercus cerris					
leaf, shade-adapted	5	4807	27.0	6.2	5126
light-adapted	5	4945	22.9	5.4	5229
twig ⌀ ≤ 1 cm	4	4629	55.1	5.3	4893
branch ⌀ 1—10 cm					
wood	3	4664	31.7	1.3	4728
bark	4	4282	24.0	8.3	4669
trunk					
wood	3	4735	16.9	1.1	4787
bark	7	4659	24.0	8.4	5081
root	3	4574	19.3	4.6	4793
fruit	3	4510	8.1	2.1	4605

Results

Caloric values

The caloric values of the various fractions of the individual species are listed in Tables 1a, 1b, 1c. The following characteristics can be pointed out. As to the green parts (trees and shrubs leaves, living parts of herbs) caloric values are decreasing from the tree layer toward the herbaceous one: mean values are 4803 for the oak species, 4364 for the shrubs and 4334 cal/g for the herbs. Higher caloric values were found for the light-adapted oak leaves than for the shade-adapted ones. Relatively great differences were found between the

Table 1b

Caloric value and ash content of shrub species

(n = number of measurements, $s_{\bar{x}}$ = standard deviation of mean values)

	n	cal/g dry weight	$s_{\bar{x}}$	ash %	cal/g ash-free dry weight
Cornus mas					
leaf	5	3987	37.1	14.0	4635
bark (stem, branch)	4	4540	16.4	10.0	4993
wood (stem, branch)	3	4669	11.3	0.7	4701
root	4	4449	13.0	8.3	4848
Cornus sanguinea					
leaf	5	4119	27.4	14.1	4796
bark (stem, branch)	5	4736	26.9	6.3	5058
wood (stem, branch)	3	4611	28.1	0.6	4634
root	3	4367	15.0	8.3	4761
Acer campestre					
leaf	6	4354	3.0	10.3	4851
bark (stem, branch)	5	4226	27.7	9.7	4683
wood (stem, branch)	4	4635	16.7	1.2	4689
root	4	4377	43.2	10.0	4861
Acer tataricum					
leaf	6	4470	61.2	5.61	4736
bark (stem, branch)	5	4428	63.5	7.5	4784
wood (stem, branch)	3	4610	29.4	0.6	4634
root	3	4308	32.1	5.8	4575
Ligustrum vulgare					
leaf	5	4688	37.6	9.0	5149
bark (stem, branch)	4	4552	53.7	4.9	4791
wood (stem, branch)	4	4621	31.8	0.7	4653
root	4	4538	28.6	6.8	4873
Eonymus verrucosus					
leaf	5	4564	45.9	9.5	5041
bark (stem, branch)	5	4749	23.8	6.3	5081
wood (stem, branch)	3	4717	9.0	0.7	4749
root	3	4614	19.8	8.1	5023

Table 1c

Caloric value and ash content of herbs

(n = number of measurements, $s_{\bar{x}}$ = standard deviation of mean values)

	n	cal/g dry weight	$s_{\bar{x}}$	ash %	cal/g ash-free dry weight
Poa nemoralis					
aboveground, living	3	4380	31.3	6.0	4661
aboveground, dead	3	4382	15.0	8.7	4798
belowground	3	4472	45.9	11.0	5014
Melica uniflora					
aboveground, living	3	4283	4.3	8.1	4665
aboveground, dead	3	4254	32.0	12.2	4850
belowground	3	4429	8.5	7.6	4795
Dactylis polygama					
aboveground, living	3	4242	20.1	12.4	4847
aboveground, dead	3	4059	40.5	15.8	4822
belowground	3	4267	47.3	10.8	4789
Carex michelii					
aboveground, living	3	4343	3.5	9.0	4718
aboveground, dead	3	4385	21.5	10.6	4904
belowground		4435	37.3	8.3	4837
Carex montana					
aboveground, living	3	4222	3.1	8.4	4827
aboveground, dead	3	3940	73.5	14.7	4614
belowground	3	4468	77.5	6.3	4764

leaves of various species in the shrub layer (the two *Cornus* species having the lowest values) a fact partly accounted for by their disparate ash contents as the caloric values of the ash-free dry weights differ less. However within the herb and the tree layers, resp. leaf values are more homogeneous.

As far as the wood is concerned, no significant differences exist between species or within species between parts (branches, stems) of different diameter. Relevant values fall between 4600 and 4750 cal/g and, in general, lie below or approach closely those of leaves.

Bark caloric values differ considerably in the species studied ranging from 4200 to 4700 cal/g. As a rule, within species the bark values lie below those of the wood, however the values of ash-free bark are higher, the primary reason being presumably the higher ash content. With the two oak species, the caloric value of the bark increases parallel with the diameter of the woody parts being thus lower for the bark of branches than of stems. RUNGE (1973) has called attention to a contrary tendency in the bark of birch and spruce.

Table 2

Phytomass (as dry weight) and its energy content (kcal/ha)

	t/ha	$\times 10^7$ kcal/ha		kg/ha	$\times 10^5$ kcal/ha		kg/ha	$\times 10^4$ kcal/ha
Quercus petraea			*Acer campestre*			*Carex michelii*		
foliage	3.78	1.788	foliage	199.07	8.668	aboveground living	22.41	9.733
branch	51.02	23.366	stem + branch	1311.11	58.632	aboveground dead	12.51	5.486
stem	110.91	52.372	root	753.13	32.964	belowground	36.18	16.046
root	27.11	12.183		2263.31	100.264		71.10	31.265
	192.82	89.709						
Quercus cerris			*Acer tataricum*			*Carex montana*		
foliage	0.89	0.434	foliage	46.10	2.061	aboveground living	5.34	2.363
branch	8.05	3.641	stem + branch	331.12	15.122	aboveground dead	3.82	1.507
stem	29.53	13.981	root	173.05	7.455	belowground	12.21	5.454
root	6.37	2.914		550.27	24.638		21.37	9.324
	44.88	20.970						
Total:	t/ha	$\times 10^7$ kcal/ha	*Cornus mas*			*Poa nemoralis*		
trees	237.660	110.679	foliage	185.28	7.387	aboveground living	68.95	30.201
shrubs	6.242	2.794	stem + branch	1905.54	86.987	aboveground dead	33.88	14.847
herbs	0.395	0.173	root	675.17	30.037	belowground	85.53	38.251
	244.297	113.646		2765.99	124.412		188.36	83.299
			C. sanguinea			*Melica uniflora*		
			foliage	29.79	1.227	aboveground living	32.59	13.959
			stem + branch	146.67	6.858	aboveground dead	55.28	23.517
			root	119.65	5.225	belowground	14.42	6.387
				296.11	13.310		102.29	43.863
			Ligustrum vulgare			*Dactylis polygama*		
			foliage	15.57	0.730	aboveground living	4.52	1.917
			stem + branch	71.09	3.283	aboveground dead	3.51	1.423
			root	162.15	7.358	belowground	4.25	1.815
				248.81	11.371		12.28	5.155
			Eu. verrucosus					
			foliage	7.39	0.337			
			stem + branch	26.90	1.267			
			root	83.94	3.873			
				118.23	5.477			

Great differences can be observed also between the caloric values of the roots of different species. It is interesting furthermore that oak acorns do not claim a high rank with respect to caloric value.

Averaging the individual fractions caloric values are obtained for the dominant species in cal/g. Trees: *Quercus petraea* 4652, *Quercus cerris* 4672; shrubs: *Cornus mas* 4498, *Cornus sanguinea* 4495, *Acer campestre* 4430, *Acer tataricum* 4477, *Ligustrum vulgare* 4570, *Euonymus verrucosus* 4632; herbs: *Carex michelli* 4397, *Carex montana* 4363, *Poa nemoralis* 4422, *Dactylis polygama* 4198. Obviously species belonging to the same genus have nearly identical caloric values. On the other hand, moving toward the ground layer a decrease in caloric values becomes apparent since for trees 4647, shrubs 4476, herbs 4379 cal/g are the means. With the exception of slight differences our measurements agree fairly well with comparable data (OVINGTON—HEITKAMP, 1960; GOLLEY, 1961; RUNGE, 1973, etc.).

Energy content of phytomass

The energy content of the phytomass, calculated in kcal/ha for layers, species and fractions, has been derived from the caloric values and the phytomass (regarded as dry weight). Results are summarized in Table 2. Tree and shrub phytomass is estimated by regression analysis on the basis of measurements taken on felled samples (KÁRÁSZ, 1974; B-PAPP, 1974), data on the phytomass of herbaceous vegetation have been taken over from the communication of JAKUCS and PAPP (1974).

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NEW OR LITTLE KNOWN EPIPHYLLOUS LIVERWORTS I.

COLOLEJEUNEA FROM TROPICAL AFRICA

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Cololejeunea fadenii spec. nov. from Mt. Kenya; *Cololejeunea harrisii* spec. nov. and *Cololejeunea jonesii* spec. nov. from the Uluguru Mts., Tanzania, are described. The description of the rare *C. usambarica* E. W. Jones is completed. *Aphanolejeunea runssorensis* Steph. is transferred into *Cololejeunea* and synonymized with *C. leonardii* Vanden Berghen.

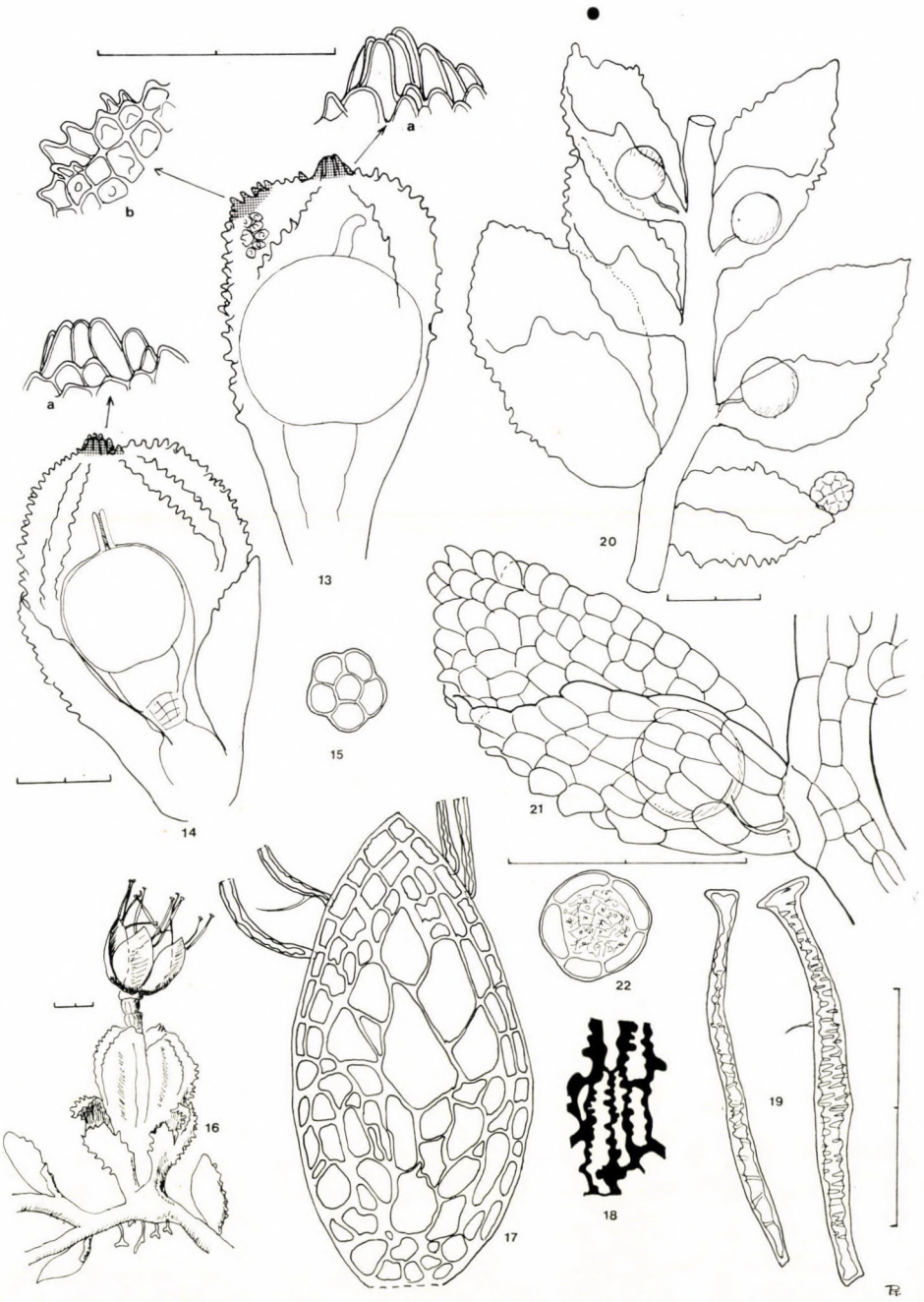
This study is the first paper of a series of taxonomic observations to be made on epiphyllous liverworts. Although the available material of African *Cololejeunea* was thoroughly revised by E. W. Jones (1953, 1953, 1954, 1957, 1968), many new collectings were made by the author and his colleagues, which either modify the known range of distribution of African taxa, or contribute new taxonomical data. While one part of the floristical data were published in Bizot—Pócs (1974), this paper deals with the new taxa and with taxonomically scarcely known or misplaced species.

New taxa

Cololejeunea fadenii Pócs sp. nov. (Figs 1—22)

Planta parva, autoica, flavo-virens, foliicola: ad folium Pteridophytum caespites densos, diametro 4—10 mm formans. Caules ad 5 mm longi, 30 μm crassi, cum foliis 0.5—0.6 mm lati. Planta heterophylla: folia magna 300—350 μm longa, 150—180 μm lata, apicibus acuta; folia parva 100—150 μm longa, 70—100 μm lata, saepe in caulibus propriis disposita. Lobus dorsaliter et ad marginem gemmas 16-, 18-, vel 20-cellulares gerens. Gemmae marginales ad superficiem lobi directae. Lobus e cellulibus isodiametricis (10—18 μm diam.), parietes aequaliter tenues, extrorse mamillatos habentibus, constructus. Lobulus partem 1/2 ad 3/4 fere longitudinis lobi adaequans, in foliis magnis bene evolutus, cellulis, carina excepta, levibus. Dens apicalis elongatus, bicellularis. Dens proximalis priori vicinus, valde humilis, obtusus et saepe introrsus, non visibilis. Papilla hyalina non visibilis. Bracteae femininae 180—250 μm longae. Perianthium 400 μm longum, 200—250 μm latum, pyriforme, brevirostratum, 5-carinatum, carinis inter se aequalibus. Cellulae perianthii mamillato-spinosae. Sporangium globosum, diametro 180 μm. Elaterae 160 μm longae. Androecea in ramulis pseudapicalibus, longitudine perianthium superantibus, orta, bracteis in 3—5 jugis. Bracteae foliis sterilibus similes, distantes. Antheridia solitaria, longe-pedunculata. Speciem novam in honorem A. J. et R. B. Faden, collectorium eius primorum, nominavi.

Cololejeunea fadenii Pócs n. sp. Fig. 1: Shoot apex with male spikelet and two perianths. 2—3: Perianths seen from above. 4: Part of shoot with one normal and two reduced leaves. 5: Mamillosity of lobe. 6: Mamilles in section. 7: Primordium of a discoid gemma. 8—9: Normally developed leaf lobules. 10: Shoot formed by reduced leaves. 11: Discoid gemma, transversal section. 12: Gemmae seen from above. All drawn from the type. Note: the scale given near the figures indicates 100 μm (0.1 mm), divided into two halves of 50—50 μm.



Cololejeunea fadenii Pócs n. sp. Figs 13—14: Perianths; a: perianth mouth, b: edge of carene. 15: Transversal section of stem. 16: Open perianth with sporophyton. 17: One segment of sporangium wall. 18: Inner cell layer of sporangium wall. 19: Elateres. 20: Male bracts bearing shoot. 21: One male bract with an antheridium. 22: Transversal section of an antheridium. All drawn from the type.

A relatively small, yellowish green, autoicous plant, living in 4—10 mm large, round patches on fern leaves. Shoots up to 5 mm long, 0.5—0.6 mm broad, diameter of stem 30 μm. The stem is composed of 1 medullary and of 5 rows of cortical cells. Heterophyllous, bearing large leaves 300—350 μm in length and 150—180 μm in width; and small, reduced leaves 100—150 μm in length and 70—100 μm in width. The reduced leaves often form separate, gemmiferous shoots. The lobus of leaves bears both intramarginal and marginal discoid gemmae. The latters are perpendicular to the leaf surface. The gemmae are composed of 16, 18 or 20 cells. The lobus cells are isodiametric, 10—18 μm in diameter, with thin, even cell walls, dorsally mamillate. The mamilla of the cells is conical, acute. The lobulus is large, longer than the half of the lobus. The lobulus cells are smooth except the keel. The free margin of the lobule is always strongly inflexed, with a well developed, bicellular apical tooth. The proximal tooth is very near, short, obtuse or obsolete. Hyaline papilla is not visible. The female bracts are 180—250 μm long covering 1/2—3/4 of the 400 μm long, 200—250 μm broad, pyriform perianth. The perianth bears 5 equal, sharp or obtuse carenes and a short beak. All perianth cells, especially those of the carenes, are acutely mamillate. The sphaeric sporangium is 180 μm in diameter, the elaters are 160 μm long. The male bracts are distant and in shape similar to sterile leaves, forming a seemingly apical spikelet, twice longer than the seemingly lateral perianth. Each male bract bears one sole antheridium. The new species is dedicated to its collectors.

Holotype: East Africa, Kenya, Nyandarua District. On the S slope of Mt. Kenya. Epiphyllous in montane rain forest rich in tree ferns; along the Kamweti track, crossing the Gathiba River upstream to the waterfall, above Castle Forest Station, at 2300 m altitude. Collected by Miss A. J. EVANS (recently Mrs. FADEN), Mr. R. B. FADEN; accompanied by Messrs. B. KARIUKI and F. S. MWENDA, on 31 January, 1971. s.n. The delicate liverwort forms almost pure, yellowish green patches on fern leaves belonging to different species. It is accompanied by a few shoots of *Cololejeunea xaverii* (Lecout.) E. W. Jones and by *Taxilejeunea conformis* (Mont.) Steph. The holotype is deposited in EGR, isotypes are in BP, DSM, EA, JE and in the herbarium of R. B. FADEN.

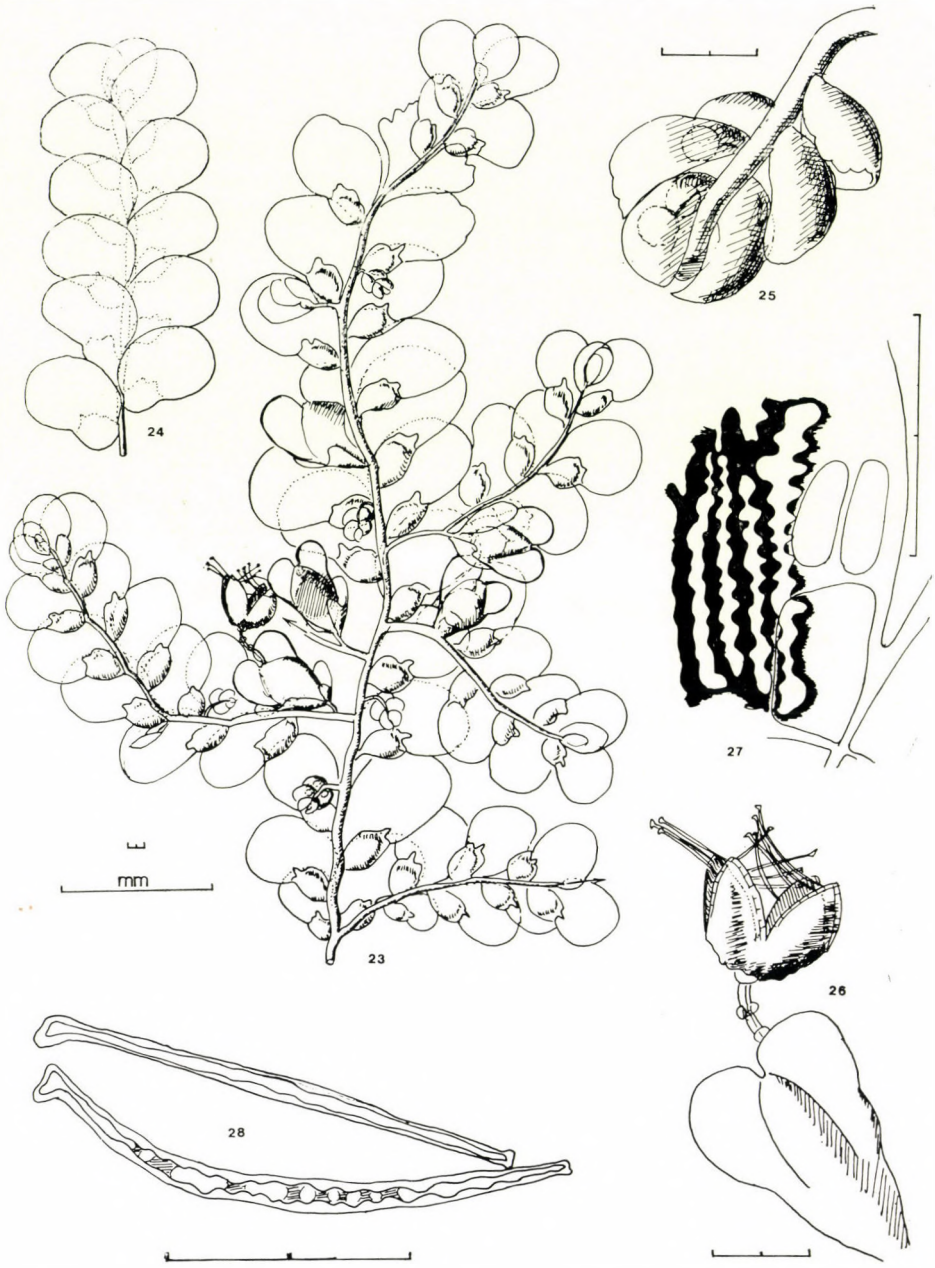
The taxonomic position of this new species reflects well the difficulties separating *Cololejeunea* and *Aphanolejeunea*. Some characters, as the heterophylly, the large, inflexed lobules, the presence of marginal gemmae, are *Aphanolejeunea*-like, but on the other hand, the relatively large size, the presence of intramarginal gemmae in larger number and the shape of the apical tooth refer to *Cololejeunea*, according to the characters given in EVANS (1911) and SCHUSTER (1955, 1963). Within the genus *Cololejeunea* the comparable species, small-sized for this genus, are in Africa: *Cololejeunea myriantha* (Herz.) S. Arnell, with a similar perianth and male inflorescence, but more

antheridia per bract, a very different leaf and cell shape; *Cololejeunea dissita* E. W. JONES with a different leaf and lobule shape and with different cells. As far as the genus *Aphanolejeunea* is concerned, there are two species described by STEPHANI in tropical Africa and one from South Africa diagnosed by S. ARNELL. Of the species described by STEPHANI, *Aphanolejeunea zenkerii* (Stephani 1916: 858) was transferred to *Cololejeunea* by E. W. JONES (1954: 420). *Aphanolejeunea runssorensis* also belong to *Cololejeunea* (see page 371), and is not related to the new species. The third one, *Aphanolejeunea capensis*, even if it was described first as a *Cololejeunea* by S. ARNELL (1953: 161) and later transferred to *Aphanolejeunea* (S. ARNELL 1963: 172), well fulfills the criteria of the latter genus and differs from *Cololejeunea fadenii* by its much smaller size and by the lack of intramarginal gemmae. *Aphanolejeunea capensis*, a very delicate foliicolous plant known from the Cape and Transvaal, was collected by the author also in East Africa (see page 361).

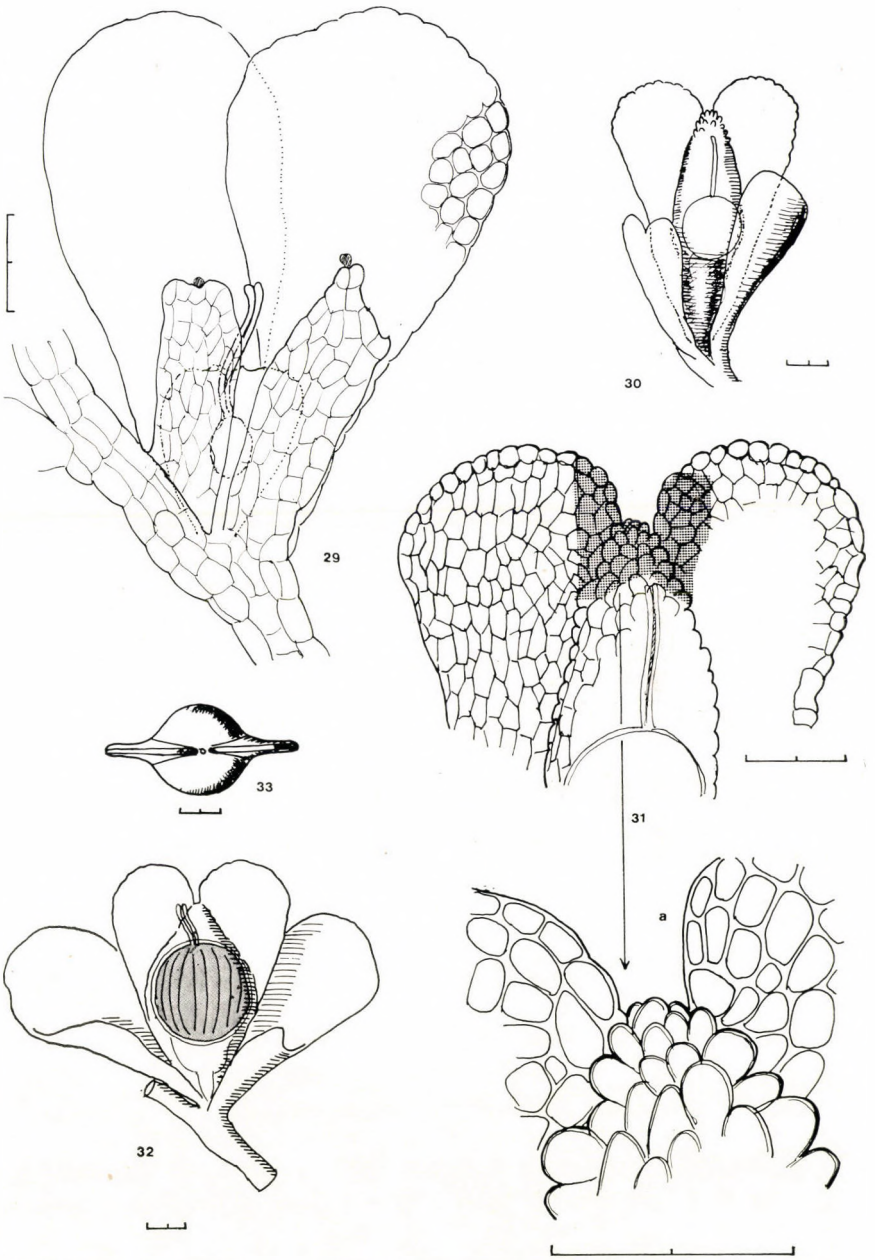
Cololejeunea harrisii Pócs sp. nov. (Figs 23—34)

Planta magnitudine media, pallide olivaceo-virens, foliicola, ad folium Pteridophytum reptans, caulibus pinnate ramosis, ad 10 mm longis, 70 μm crassis, una cum foliis 1.2—1.5 mm latis, foliis contiguis vel subimbricatis, 0.6—1 mm longis et 0.4—0.6 mm latis, suborbicularibus. Margo lobi cellulis elongatis (25—40 × 10—18 μm), uniseriatis, non hyalinis. Cellulae sub margine quadrangulares; mediae lobi hexagonales, diametro 40—50 μm; basales 50—60 × 20 μm. Cuticula levis, cellulae sine triangulis. Lobulus ad partem 2/3 inflatus, margine et apice planus. Dens apicalis bicellularis, apice rotundatus, e cellulis isodiametricis constructus. Papilla hyalina proximalis, lateralis. Stylus non visibilis. Dens proximalis subnullus, humilis, saepe absens. Perianthia e basi angusta obcordata, compressa, auriculato planissime dilatata, margine crenulata, ad ostium cellulis mamillatis; mature 500—600 μm longa, 400—500 μm lata, bracteis partem 2/3 ad 4/5 longitudinis attingentibus. Sporangia sphaerica, diametro 140 μm, elateris 80—120 μm longis. Androecea lateralia, bracteis in 2—3 jugis. Bracteae fertiles cum 1—2 antheridiis. Gemmae ignotae. Speciem hanc dedicavi in honorem professoris B. J. HARRIS, socii mei amicissimi in excursionibus nostris compluribus collectionis gratia absolutis.

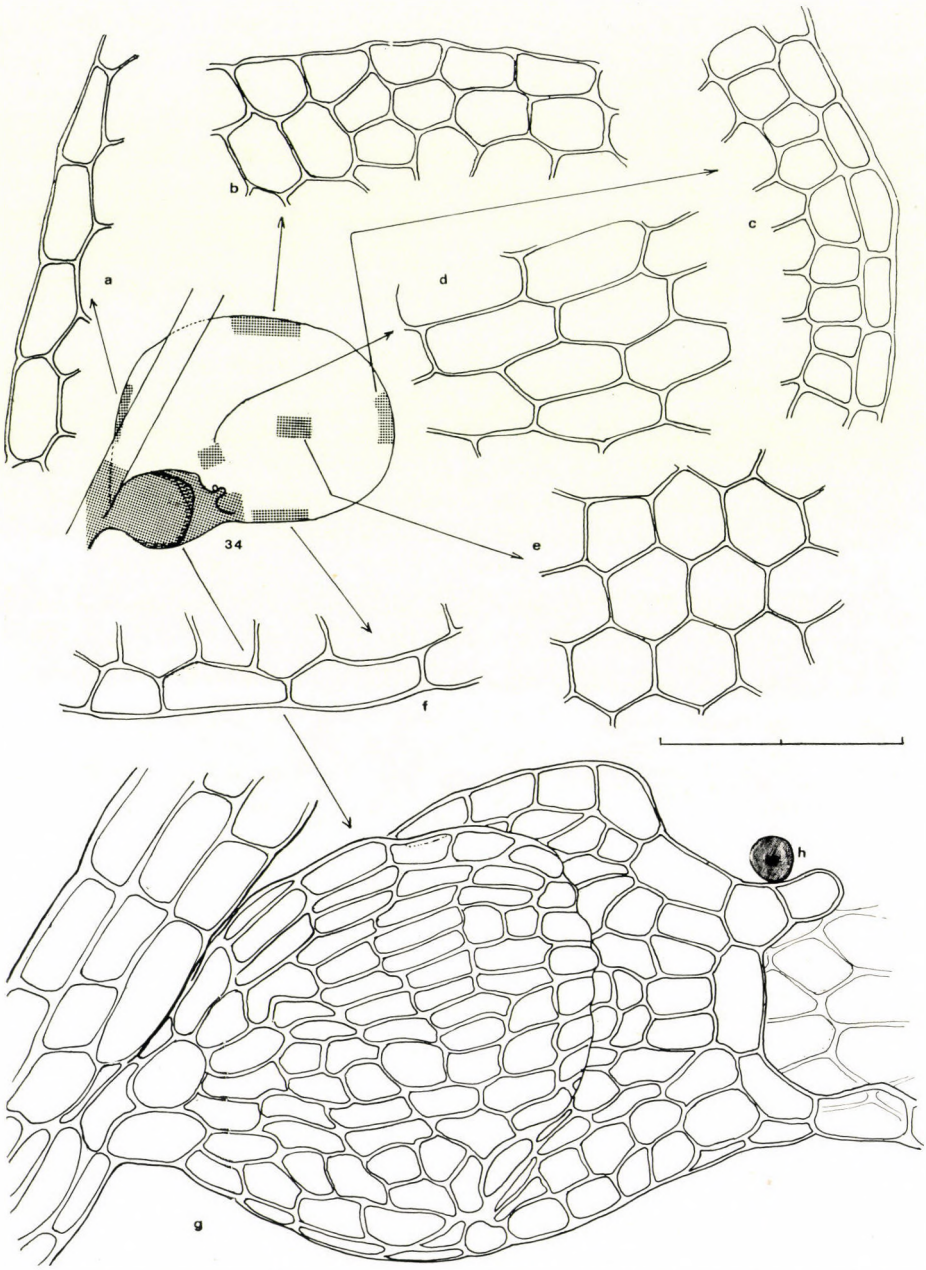
A medium-sized, pale olivaceous green, autoicous plant creeping on fern leaves. Shoot pinnately branched, up to 10 mm long, 1.2—1.5 mm broad. Stem diameter 70 μm. The leaves are contiguous or slightly imbricate, 0.6—1 mm long and 0.4—0.6 mm broad, rounded, widest near the middle. The marginal cells are elongated, forming an undistinct, *Mniaceae*-like border. The lobus cells are subquadrangular below the margin, hexagonal with 40—50 μm diameter in the center of the lobe and elongated, 50—60 × 20 μm at the leaf base. The cell walls are evenly thickened, smooth. The lobule is obovate 2/5 lengths of the lobe, its proximal 2/3 is inflated, the apical part and margin are flat. The apical tooth is usually composed of two rounded cells with a globose hyaline papilla at the proximal margin of the tooth. The proximal tooth is very broad and low, formed by 1—2 slightly protruding cells of the lobule margin, sometimes lacking. The perianths are heart-shaped, broad



Cololejeunea harrisii Pócs n. sp. Fig. 23: Branching system with perianths and male spikelets seen from below. 24: Shoot seen from above. 25: Male spikelet with antheridia. 26: Open perianth with sporophyton. 27: Inner (and outer) cell layers of sporangium wall. 28: Elateres. All drawn from the type.



Cololejeunea harrisii Pócs n. sp. Fig. 29: Female bracts with young perianth and archegonium. 30: Mature perianth. 31: Perianth apex; a: perianth mouth. 32: Perianth with developing sporophyton. 33: Perianth seen from above. All drawn from the type.



Cololejeunea harrisii Pócs n. sp. Fig. 34: Leaf structure; a: cells of proximal margin of lobe, b: same of antical margin, c: of lobe apex, d: of base of lobe, e: median cells of lobe, f: cells from postical margin, g: lobule. All drawn from the type.

auriculate-winged, flat, except the central, spindle-like inflated part. Their cells, especially near the mouth, are rounded protuberant, therefore the carenes are slightly crenulate. The perianths are 0.5—0.6 mm long and 0.4—0.5 mm broad, with bracts 0.4—0.5 mm in length. The diameter of mature sporangia is 140 μm. The elaters are 80—120 μm long with strongly sinuous incrassated walls. The male spikelets are lateral on the main axis or on the branches,formed by 2—3 pairs of bracts, each with 1—2 antheridia. Gemmae are not seen.

The new species is dedicated to prof. B. J. HARRIS (Ahmadu Bello University, Zaria, Nigeria), who often accompanied and helped me in many ways during my stay in East Africa.

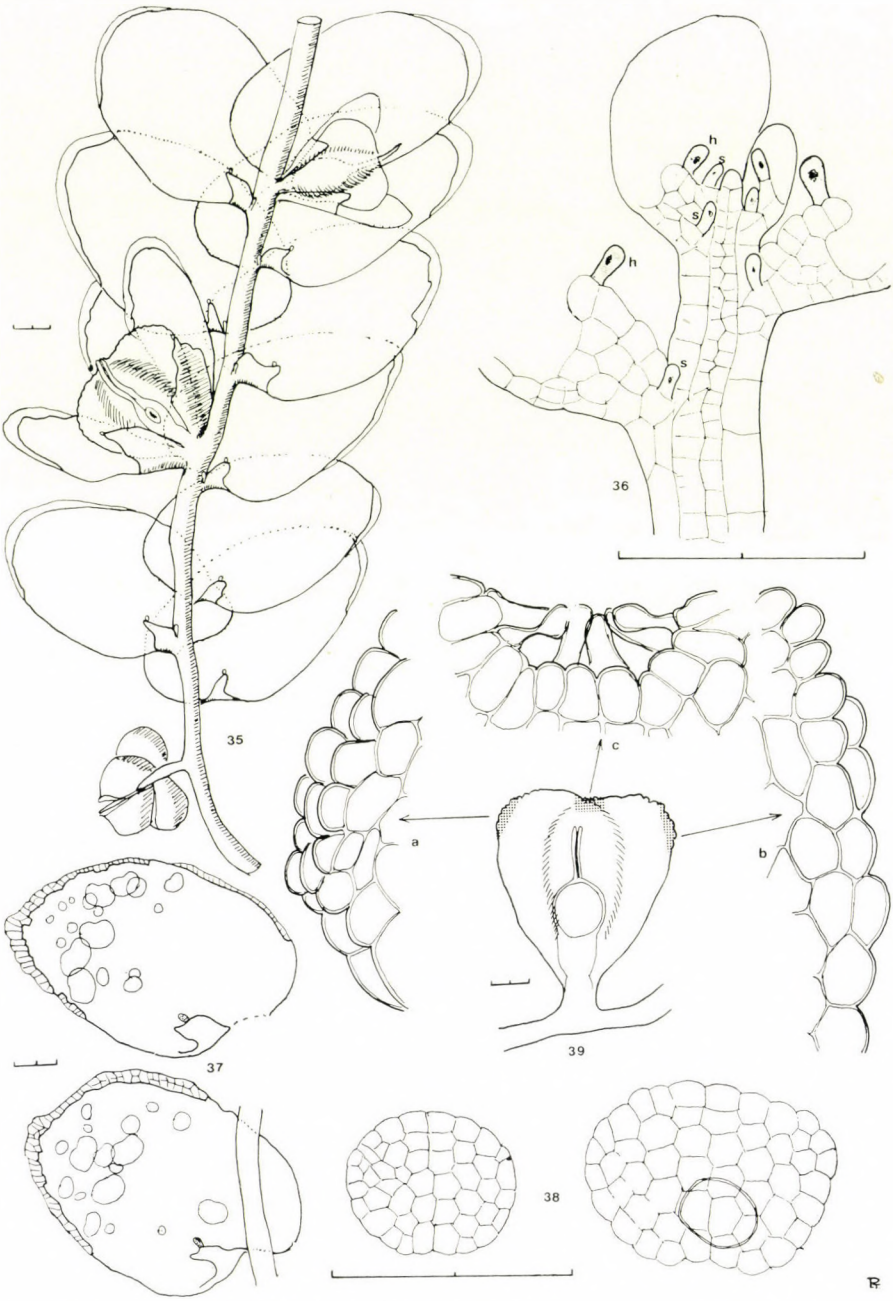
Holotype: East Africa, Tanzania, Morogoro District, Uluguru Mts. Epiphyllous on *Tectaria* leaves in montane mossy forests with many tree ferns on the NW slopes of the Lupanga crest, at 1800—2000 m altitude, associated with *Aphanolejeunea capensis* (S. Arnell) S. Arnell, collected by T. PÓCS and B. J. HARRIS, No. 6130/S, on 14 Feb., 1970. Holotype deposited in EGR, isotypes in DSM, BP.

This very characteristic *Cololejeunea* is quite isolated in Africa, with its peculiar leaf margin cells and by its compressed, heart-shaped, auriculate-winged perianth. The latter suggests affinity with some Asian members of the subgenus *Lasiolejeunea*, but the lack of papillae precludes this relation. The only African species with such a perianth, *Cololejeunea apiculata* (E. W. Jones) Schuster, has a very different, acute-pointed lobe and a flat lobule with a hyaline papilla at the apex of an enormous, pluricellular tooth. The shape of the lobe and lobule and the position of the hyaline papilla show the nearest affinity with the members of the Sectio *Crenatiflorae* within the Subgenus *Platycolea*, but with a very different kind of leaf margin.

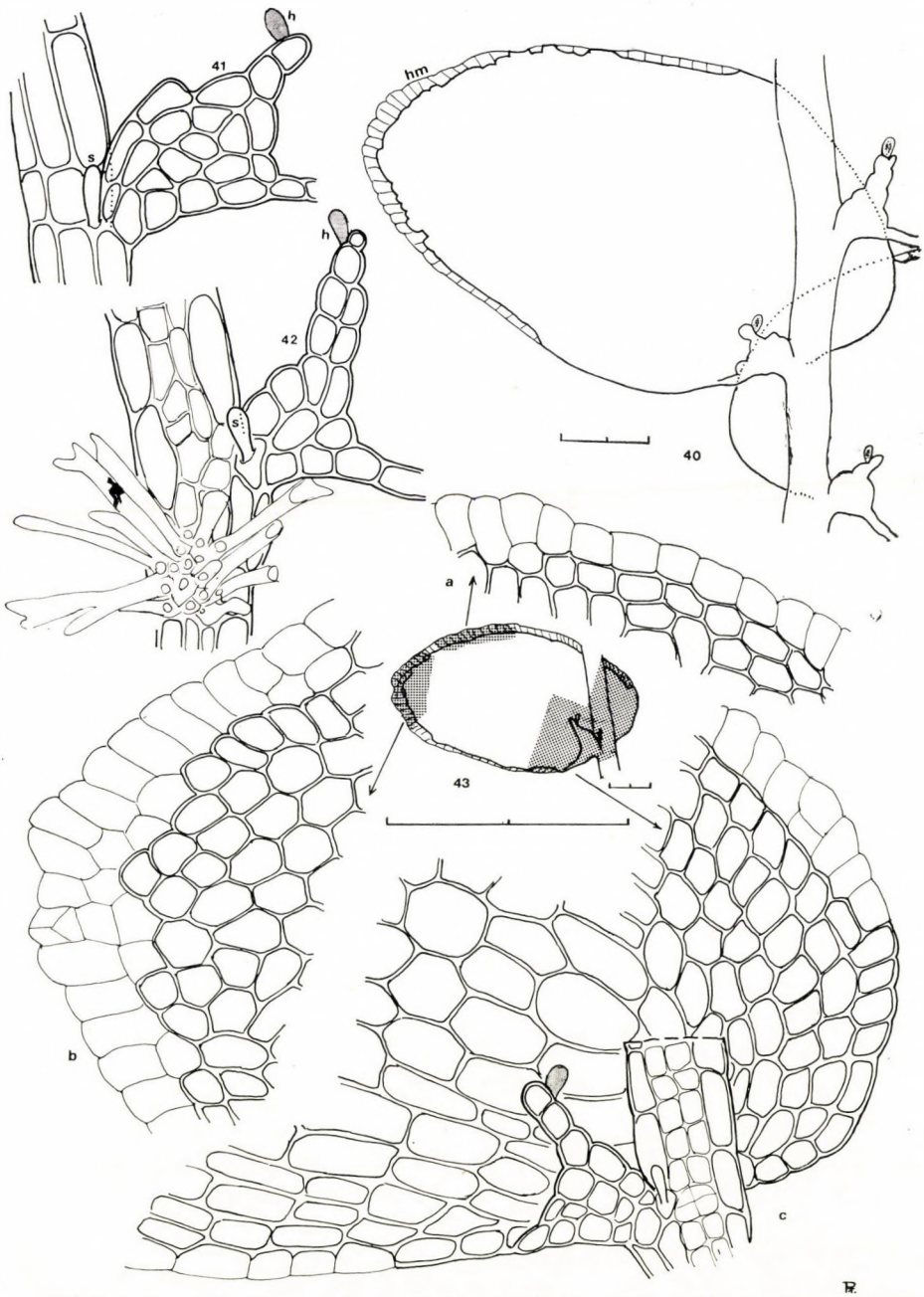
Cololejeunea jonesii Pócs sp. nov. (Figs 35—43)

Planta magnitudine media, autoica, pallide virens, foliicola, in statu juvenili ad folia adhaerens, serius laxe applicata. Caulis 40—50 μm crassus, regulariter cum merophytis biseriatis, cum foliis 1 mm latus, 5—10 mm longus, colonias diametro 10—20 mm formans. Folia asymmetrica, subcordata, imbricata, caulem valde superantia. Lobus 1/3—3/4 hyaline marginatus: cellulis hyalinis 1—2 seriatis, subquadrangularibus. Cellulae submarginales diametro 10—20 μm, centrales 18—32 μm, basales 15—20 μm, subisodiametricae, parietibus leves, sine trigonis vel trigonis minimis. Lobulus parvulus, ligulatus vel trianguliformis. Dens apicalis elongatus, in longitudinem 2—5-cellularis, cellulibus 1—2-seriatis. Papilla hyalina magna, subapicalis, proximalis. Stylus unicellularis, clavatus. Gemmae e 40—50 cellulis compositae, in superficie loborum densissime evolutae. Perianthia e basi angusta obcordata, compressa, bialata, in marginibus cellulis lentiformiter prominentibus, 500 μm longa, 400 μm lata, bracteis mature aequilongia. Androecea lateralia, 2-jugata. Species dedicata in honorem dr. E. W. JONES, auctoris monographiae specierum Africanarum generis Cololejeuneae.

A medium-sized, pale green, autoicous plant, forming 1—2 cm large mats on sclerophyllous, evergreen leaves. The shoots are 5—10 mm long, 1 mm broad; when young, strongly appressed to the surface. The stems are 40—50 μm thick, usually with two cells broad ventral merophytes. The leaves



Cololejeunea jonesii Pócs n. sp. Fig. 35: Fertile shoot seen from below, with a male spikelet and two perianths. 36: Growing point of shoot apex. The hyaline papillae (h), styli (s) and the ventral merophytes are well visible. 37: Two gemmiferous leaves. 38: Discoid gemmae. 39: Mature perianth; a—b: carene edges, c: perianth mouth. All drawn from the type.



Cololejeunea jonesii Pócs n. sp. Fig. 40: Leaf with hyaline margin (hm). 41—42: Leaf lobules with stylus (s) and hyaline papilla (h). 43: Leaf structure; a: antical margin, b: lobus apex, c: leaf base with lobule. All drawn from the type.

are asymmetric cordate, narrowed towards the apex and hyaline-bordered from 1/3 to 3/4 lengths of their margins. The hyaline border usually fails to reach the keel and is composed of a single or double row of cells with an almost entire or slightly crenulate margin. The young leaves bear a large, clavate, unicellular stylus. The lobe cells below the margin are 10—20 μm wide, in the center 18—32 μm and at the base 15—20 μm wide, subquadrangular or slightly elongately hexagonal, with smooth walls. The lobule is extremely small, triangular or ligulate, prolonged into a uni- or biseriate, acute tooth bearing a large, proximal papilla just below the apex. The whole lobulus is composed of 10—24 cells and its length is about 1/10 of the lobe. Discoid gemmae abundantly develop on the lobe surface, composed of 48—50 cells. The perianth is heart-shaped, compressed, about 0.5 mm long and 0.4 mm broad. The edge of the carene is crenulate with lentil-shaped, slightly protuberant cells. The perianth mouth is surrounded by arched, clavate cells. The female bracts are as long as the mature perianths, their lobe is hyaline-bordered. The male bracts are in 2 pairs, arranged in lateral spikelets.

The new species is dedicated to Dr. E. W. JONES (Commonwealth Forestry Institute, Oxford), monographer of the African *Cololejeunea*.

Holotype: East Africa, Tanzania, Morogoro District. Kimboza Forest Reserve on the carstic plateau at the eastern foothills of Uluguru Mountains. Epiphyllous in semi-evergreen lowland rain forest, at 300 m altitude. Collected by T. PÓCS and B. J. HARRIS, No. 6023/A, on 6 September, 1969. Holotype in EGR, isotypes in BP, G, DSM, EA, Herbarium of E. W. JONES.

The species was recollected several times at the type-locality (PÓCS 6216/A, 6236/A, 6273/A in EGR, DSM), where it is abundant, associated with foliicolous bryophytes typical to African lowland rain forests, as *Cololejeunea leloutrei*, *C. pusilla* et ssp. *obtusifolia*, *C. furcilobulata*, *Leptolejeunea quintasii*, *Caudalejeunea africana*, *Cheilolejeunea africana*, *Radula flaccida* and *Calymperes usambaricum* (see BIZOT—PÓCS 1974).

The new species seems to be related to *Cololejeunea auriculata* by its reduced lobule, but well differs by its other lobe and lobule shape (see E. W. JONES 1953: 152—154). The lobus is much narrower towards the apex and its base much more asymmetric, while the lobule ends in a single or double row of cells. The other comparable species, *Cololejeunea bolombensis* (E. W. Jones) Schuster, though with an asymmetric leaf base, has also a broad, rounded leaf apex and its lobule is composed of much more and of elongated cells (see E. W. JONES 1953: 155, TIXIER 1975: 28—33). As indicated by VANDEN BERGHEN (1972: 475) and by TIXIER (l.c.), *Cololejeunea bolombensis* has a perianth with a beak and the leaf cuticle is usually papillose. The number of cells in the discoid gemmae in *C. jonesii* is much higher than in the related species. The presence of claviform styles and the biserial ventral merophytes also appear to be good distinguishing characters.

Other taxonomical observations

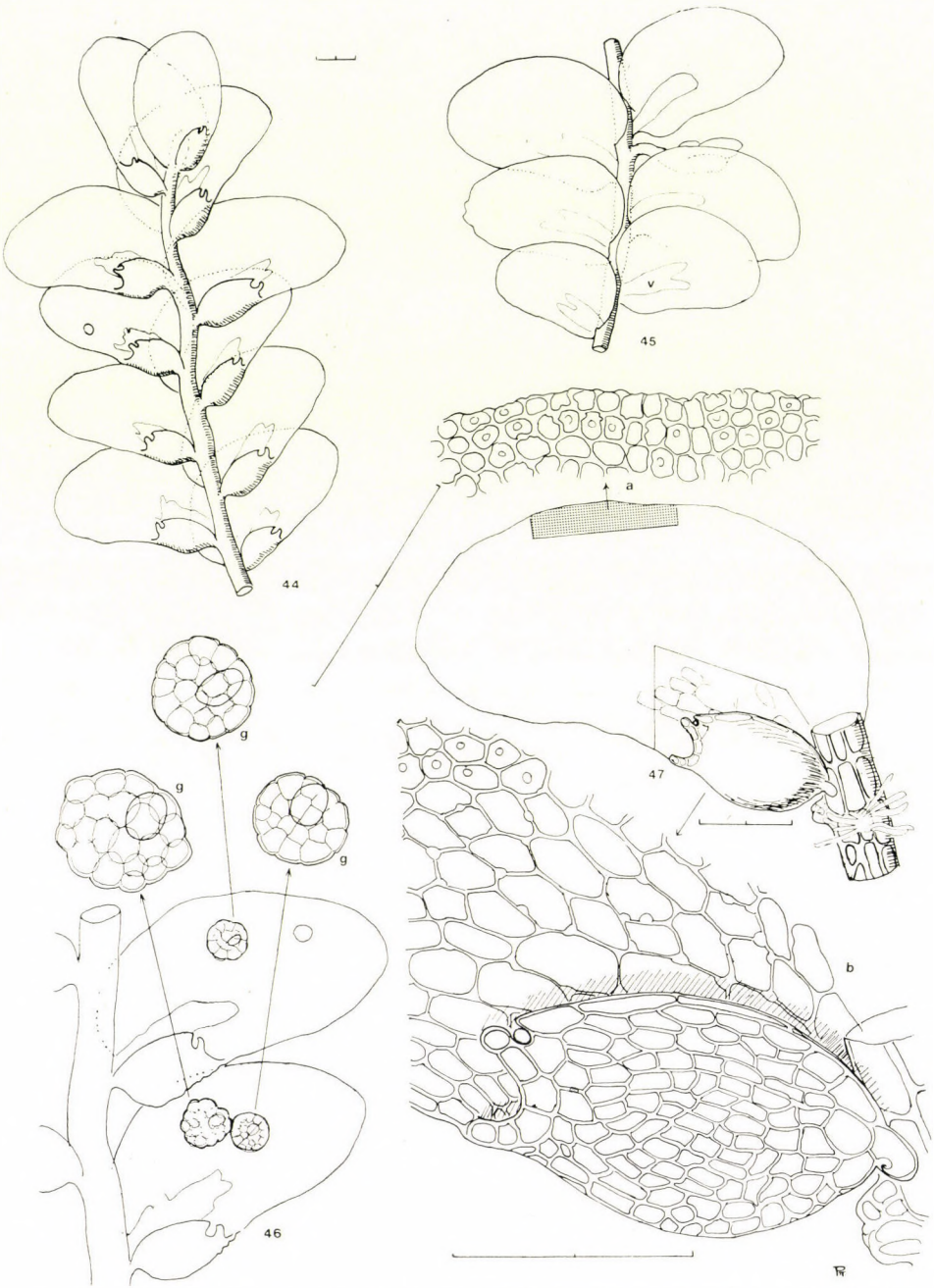
The taxonomic position of Cololejeunea usambarica E. W. JONES

(see Figs 44—63)

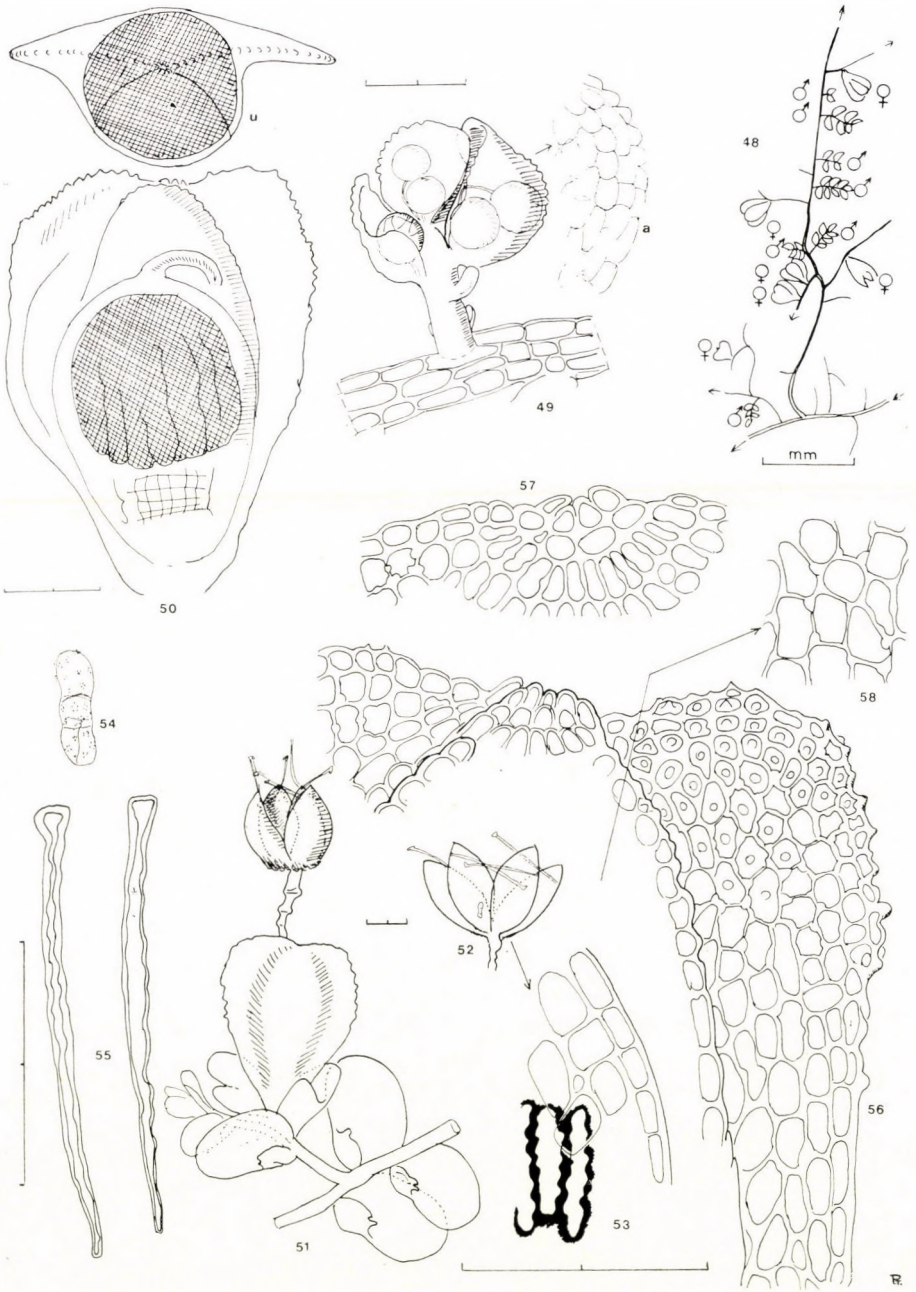
The author published a new locality of *Cololejeunea peraffinis* Schiffn., with its var. *elegans* Benedix, from Tanzania, Uluguru Mts., Mt. Lupanga (BIZOT—PÓCS 1974: 410). The specimen seemed atypical, but on the base of an indistinct vitta was conveniently classified here, the Asian species being known from West Africa. The other members of the subgenus *Taeniolejeunea* represented in Africa are more different. Later, the same plant was found abundantly in another epiphyllous collection, from the NE part of the Uluguru Mountains, and its hyaline papilla was observable. It became clear that this plant is n o t *Cololejeunea peraffinis* (see Figs 59—60, where it is compared with a typical Vietnamese specimen of *C. peraffinis* var. *elegans*). Whereas the hyaline papilla of *Cololejeunea elegans* is on the inner base of the apical tooth, therefore not visible, in our plant it has a marginal position between the two teeth. On the other hand, the free margin of the lobule is composed of only 4—6 very elongated cells. In *C. elegans*, this margin consists of 9—12 much shorter, rectangular cells. The vitta in our plant is indistinct and shows a gradual transition into the papillose lobe cells. In *Cololejeunea elegans*, the vitta is quite sharply defined. E. W. JONES' paper in question (1968: 571), in which he enumerates *Cololejeuneas* belonging to the subgenus *Taeniolejeunea*, refers to a probably African *Taeniolejeunea* described by STEPHANI under the name of *Physocolea vittata* (STEPHANI 1916: 873—874). E. W. JONES studying STEPHANI's material of this species, rejected the name *Physocolea* = *Cololejeunea vittata*, as a nomen confusum, because he found in the Stephani Herbarium (G) three different species under this name, originating from three different localities: two of them from the Usambara Mts. in East Africa and one from New Guinea. The locality given in STEPHANI's description is "Africa orientalis, Usambara". E. W. JONES introduced a new name for the specimen chosen from the three plants, describing it as *Cololejeunea usambarica* (E. W JONES 1954: 434—435).

Studying the type-specimen of *Cololejeunea usambarica* E. W. Jones (*Physocolea vittata* Steph. p.p., G, No. 17499 ex Hb. LEVIER No. 4530), it was found on the one hand that the proposal for the new name was correct, while on the other hand the plant published under the name *C. peraffinis* from the Uluguru Mts. by the author is identical with *Cololejeunea usambarica* E. W. Jones.

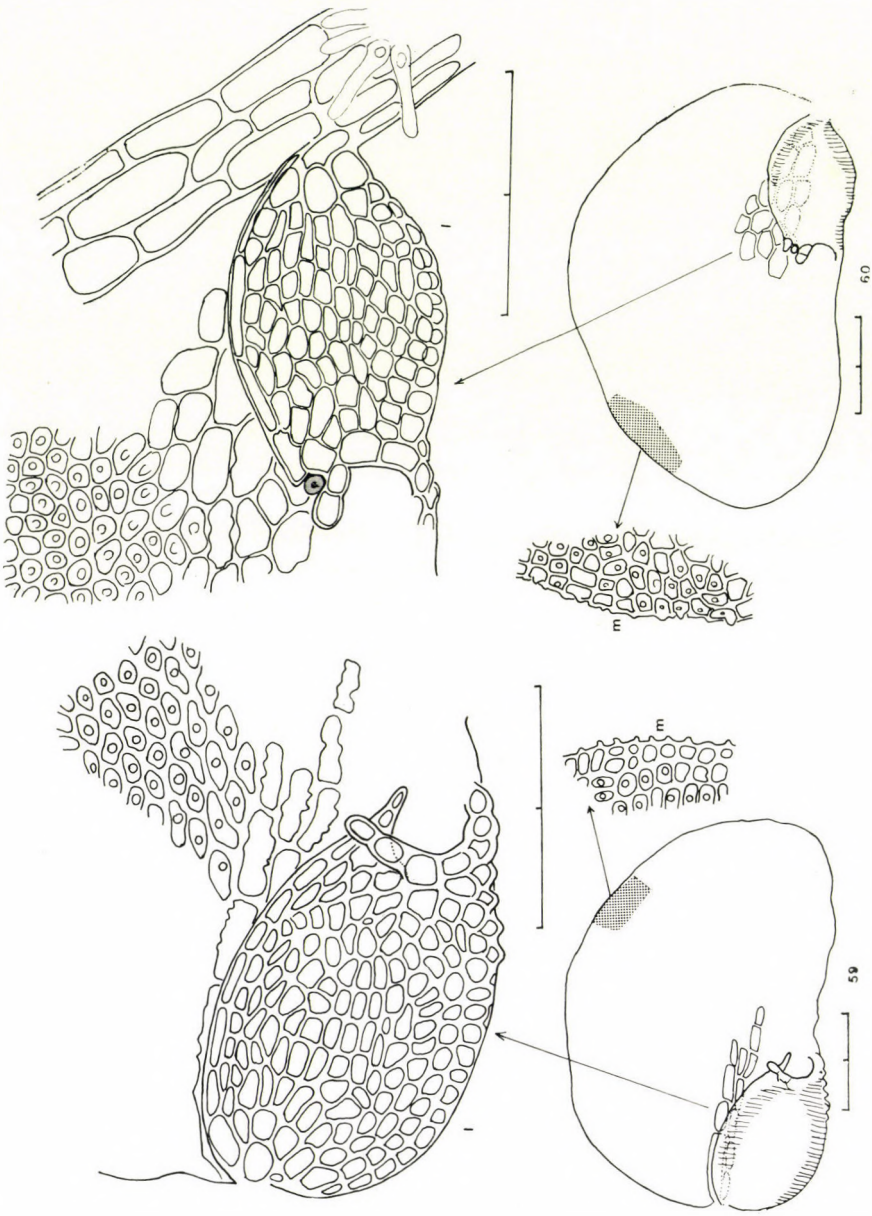
At the same time, we have to establish that STEPHANI had a reason describing the Usambaran species as vittate, even though its vitta is not sharply delimited, but still visible in all studied leaves of the specimens.



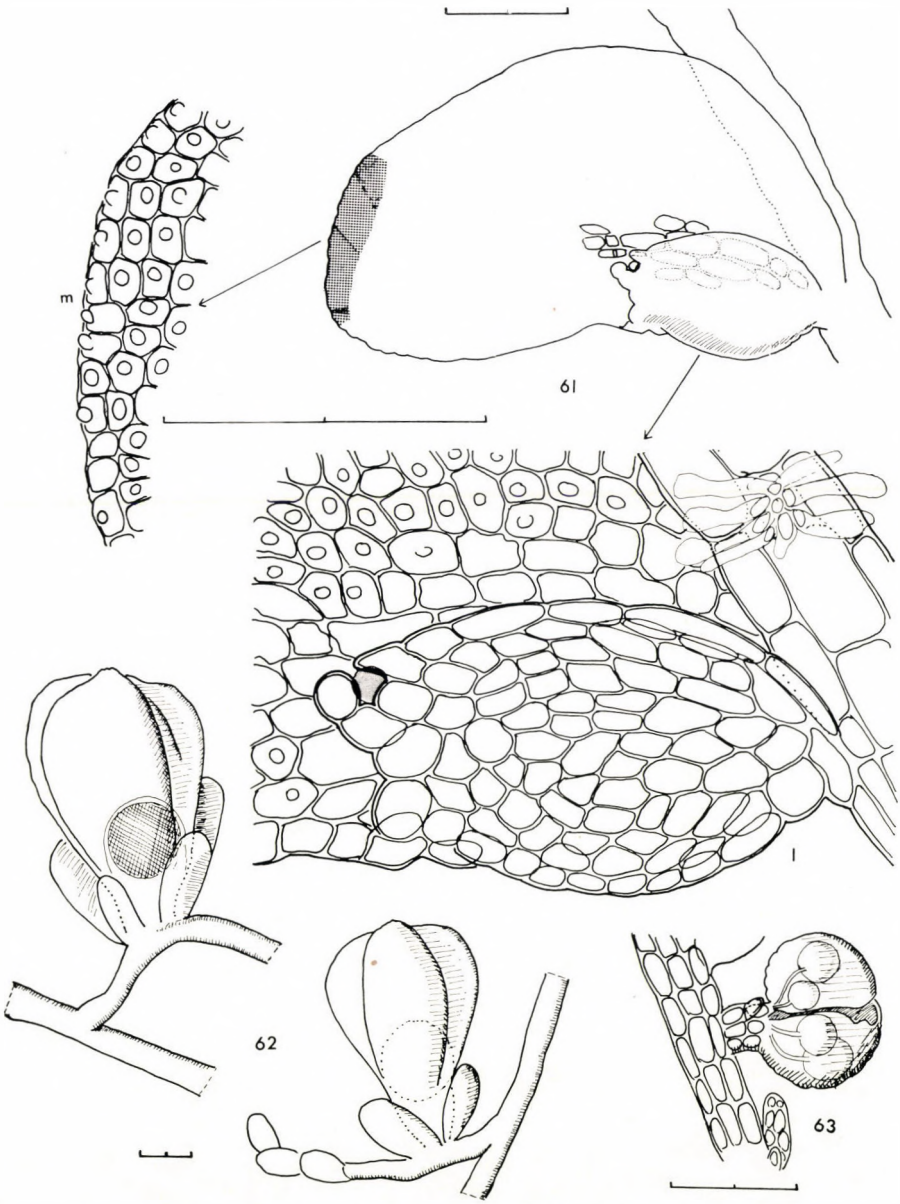
Cololejeunea usambarica E. W. Jones. Fig. 44: Shoot seen from below. 45: Shoot seen from above. 46: Leaves with gemmae (g). 47: Leaf structure; a: antical margin, b: lobule and vitta-like cells from leaf base. All drawn from PÓCS and HARRIS No. 6130/Q.



Cololejeunea usambarica E. W. Jones. Fig. 48: The position of gametangia in the branching system. 49: Male spikelet with antheridia. 50: Perianth with developing sporophyton; u: same seen from above. 51: Open perianth with sporophyton. 52: Sporangium, open stage, with a spore. 53: Inner (and outer) cell layers of sporangium wall. 54: Multicellular spore. 55: Eleteres. 56: Detail of a perianth with mouth and carene. 57: Perianth mouth. 58: Cells from lower part of perianth. All drawn from Pócs and HARRIS No. 6130/Q, EGR.



Comparison of the leaves of *Cololejeunea peraffinis* Schiffn. (Fig. 59) and *Cololejeunea usambarica* E. W. Jones (Fig. 60). l: Lobules and vitta. m: Leaf margin cells. Fig. 59 is drawn from a specimen collected by J. Kornas No. 165, North Vietnam, Crête du Mt. Phan-si-pan, épiphylle sur *Hymenophyllacées*, 2400 m alt., EGR. Fig. 60 is drawn from Pócs—Lung'wecha No. 6874/AG.



Cololejeunea usambarica E. W. Jones. Fig. 61: Leaf structure; m: margin of lobe apex, 61: Lobule. 62: Perianths. 63: Male spikelet. All drawn from the type.

TIXIER, in his revision of the Asian *Taeniolejeunea* (1969: 543—594), relegates species to the subgenus with an indefinitely limited vitta, with transitions to the other lobus cells or with only a vitta-like area formed by translucent cells e.g. *Cololejeunea cambodiana* P. Tix., *C. sphaerodontoides* P. Tix.

On the specimens of *Cololejeunea usambarica* E. W. Jones, collected in the Uluguru Mountains, it was possible to study the lobe and lobule in optimal conditions, further the discoid gemmae, the position of the male and female branches and other characters. The scarcity of the type specimen did not permit STEPHANI and E. W. JONES to give full descriptions. Therefore an addition to the descriptions is given, based on the type of *Cololejeunea usambarica* E. W. Jones and on the material collected by the author in two localities from the Uluguru Mountains.

A small, autoicous, olive-coloured plant, forming 4—11 mm mats on different dicotyledonous and fern leaves. A pale, shiny, translucent group of vitta-like basal cells is appearent even through the stereomicroscope. The shoots are 0.6—0.85 mm broad, the dimensions of leaves: 300—450 μm long, 180—250 μm broad. The postical margin is slightly arched with 1—3 conically protuberant cells in the sinus. Lobe cells 7—8$\times$10—15 μm at the apex, 10—15$\times$15—20 μm in the middle, with or without small trigones and slight intermediate thickenings, but in most cases bearing a 3—6 μm broad hemisphaeric papilla above the center of the cells. At the base of the lobe a vitta-like, not sharply delimited group of large, elongate cells is present. This vitta-like band consists of 15—30 cells, it is 3—5 cells broad and 6—8 cells long. The cells in the vitta are 12—20 μm broad, 20—45 μm long, occasionally with nodulose intermediate thickenings, always translucent, without papillae. About half of the vitta is covered by the inflated, 120—150 μm long lobule. The lobule cells are smooth, quadrangular, 5—8$\times$9—21 μm. The free margin of the lobule is formed by one row of 4—6 narrow, elongated cells (dimensions: 3—9$\times$25—50 μm). The apical tooth is formed by one or two cells, ending in a sphaeric one. The proximal tooth is shorter and more acute, formed by one triangular cell. The teeth are close to each other and the hyaline papilla (also in the type) is located marginally at the proximal base of the apical tooth — practically in the unicellular sinus between the two teeth. The discoid gemmae (not present in the type) are 18—20-celled, their number is 1—3 per leaf.

The perianths are borne on the proximal part of bigger branches. They are pyriform, dorsoventrally not evenly compressed, 450$\times$350 μm. The perianth cells bear large, nodulose trigones and near the perianth apex also conical or hemisphaeric papillae. The sporangium is 200—250 μm in diameter, with very few elaters (1—2 per segment). The elaters are 160—170 μm long, with relatively thin, sinuous walls. One multicellular spore was seen in an open sporangium (Figs 52, 54), consisting of $\pm$4 cells. The sporoderm is translucent, very thin, and ornamented with small, round groups of papillae. Spore size:

50×15 μm. The male inflorescence has, as described by E. W. JONES, 1—2 antheridia per bract.

On the basis of the above mentioned characters, *Cololejeunea usambarica* E. W. Jones should be treated as a member of the subgenus *Taeniolejeunea*, within the section *Leonidentes* Benedix. The only argument against this assignment is the lack of a stylus.

The known distribution of *Cololejeunea usambarica* E. W. Jones is: East Africa, Tanzania, East Usambara Mts., Amani Botanical Garden, at 600 m alt. Epiphyllous on *Hymenophyllaceae* leaves near Sigi stream. Coll. PANDARANG JOSHI, Sept. 1903, ex Hb. LEVIER No. 4530 in G, Foundation STEPHANI No. 17499. Holotypus.

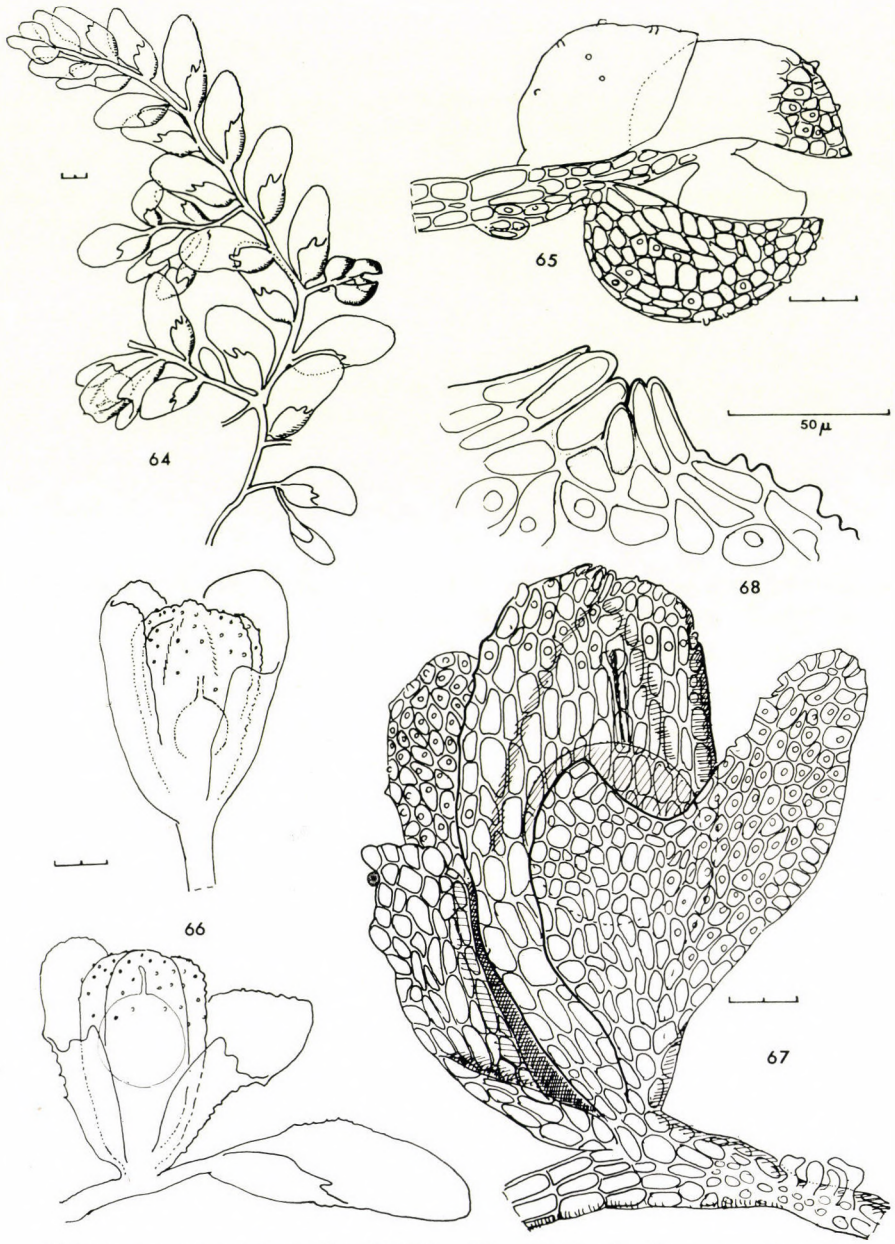
Tanzania, Morogoro District, Uluguru Mts. NW slopes of Mt. Lupanga. Epiphyllous on different dicotyledonous leaves in the mossy forest below the rocky crest, at 1800—2000 m altitude. Coll. T. Pócs and B. J. Harris, No. 6130/Q, 14. Feb. 1970. (EGR, BP, DSM under the name *C. peraffinis* var. *elegans*); N of Kinole sawmill in submontane rain forest at 1070—1100 m alt. Abundant on different dicotyledonous leaves. Coll. T. Pócs and M. Lung'wecha, No. 6874/AG, 4. Feb. 1973 (EGR, BP, DSM).

From the above data, *Cololejeunea usambarica* seems an element of the rain forests of old crystalline massives in East Africa, similarly to the range of *Saintpaulia* species among the phanerogams.

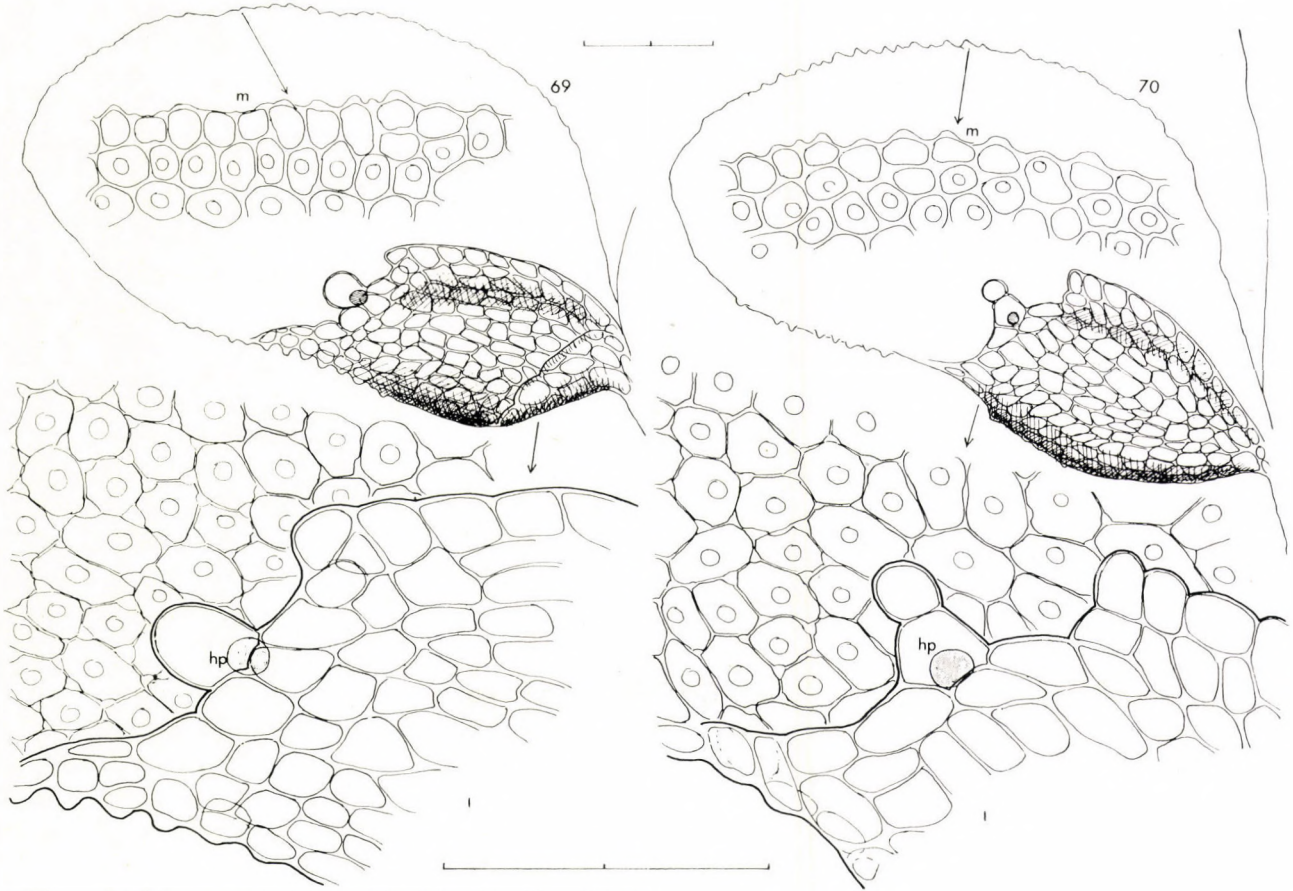
Cololejeunea runssorensis (Steph.) Pócs comb. nova (Figs 64—70)

Basionym: *Aphanolejeunea runssorensis* Steph.
Sp. Hep. 5 (1916): 858.
Syn. nov.: *Cololejeunea leonardii* Vanden Berghen
Bull. Jard. Bot. Nat. Belg. 41 (1971): 283, Fig. 22.

Studying *Cololejeunea fadenii* described above, all possibilities of comparison were taken in account, including all known African *Aphanolejeunea* species (page 357). Checking the type-specimen of *Aphanolejeunea runssorensis* Stephani (G, Foundation STEPHANI No. 17493, from Ruwenzori Mts.), it became immediately clear that this plant was a *Cololejeunea* in the strict sense. None of the generic characters of *Aphanolejeunea* is present in the plant. It is not known, why Stephani relegated the plant to the genus *Aphanolejeunea*, together with *A. zenkerii* — although the type-specimen bears a pencil mark — which most probably antedates the ink mark of *Aphanolejeunea* — clearly indicating *Colo-lejeunea* as a previous intention. Both are handwritings of STEPHANI. Similarly to *Aphanolejeunea zenkerii*, transferred by E. W. JONES to *Cololejeunea*, this species also belongs to the Subgenus *Cololejeunea* (Spr.) Schiffn., Sectio *Duvignaudii* Schust. Therefore the above new combination is proposed.



Cololejeunea runssorensis (Steph.) Pócs. Fig. 64: Fertile shoot seen from below. 65: Male spikelet. 66—67: Mature perianths. 68: Perianth mouth. All drawn from the type of *Aphanolejeunea runssorensis* Steph.



Cololejeunea runssorensis (Steph.) Pócs. Fig. 69—70: Leaf structure; m: antical margin, l: lobule with hyaline papilla (hp). All drawn from the type of *Aphanolejeunea runssorensi* Steph.

On the other hand, the author found a great similarity between this plant and the well illustrated description of *Cololejeunea leonardii* Vanden Berghen (1971: 283—286, Fig. 1 and supplemented by 1972: 480—481 with Fig. 22). Comparing the types of these species, their full identity was proved. The leaf border just reaching the stem, the typical, 1—2-celled, blunt apical tooth with the hyaline papilla at the inner base, the shape of the proximal tooth, the papillosity of the leaves, and, first of all, the shape and structure of the perianth, coincide utterly. The only differences are as follows: the plants described as *Cololejeunea leonardii* by VANDEN BERGHEN are slightly more slender than the type of *Aphanolejeunea runssorensis*. *C. leonardii* has discoid gemmae not observable on STEPHANI's plant; it has no or weakly developed trigones, which are well marked in the leaf cells of *Aphanolejeunea runssorensis*. All these variable vegetative characters are not to be taken in account in a specific delimitation.

Summarizing the geographical distribution of *Cololejeunea runssorensis*, it may be stated that it is an epiphyllous element of the extremely moist rain forests of the Central African high mountains:

Uganda: Ruwenzori Mts., Wimi, amongst tree ferns, coll. ELLIOTT 258 ex hb K in G, foundation STEPHANI No. 17493, Holotypus of *Aphanolejeunea runssorensis* Steph.

Burundi: District of Edward and Kiwu Lakes, Mt. Nyabigondo-Teza (Muramvya area), montane forest, 2300 m alt., coll. J. LÉONARD 5227. Type of *Cololejeunea leonardii* Vanden Berghen, BR, hb. Vanden Berghen; Mabayi (Bubanza area,) dense forest at 1650 m alt. Coll. J. LEWALLE No. 6254, 6259; Bugarama (Muramvya area), Ficalhoa forest, at 2100 m, coll. LEWALLE No. 5226.

ACKNOWLEDGEMENTS

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Acta Botanica Academiae Scientiarum Hungaricae, Tomus 21 (3—4), pp. 377—386 (1975)

ÜBER EINIGE PFLANZEN DES WESTLICHEN TIENSCHAN. I.

Von

Sz. Priszter

BOTANISCHER GARTEN DER EÖTVÖS-LORÁND-UNIVERSITÄT, BUDAPEST

(Eingegangen am 12. 5. 1975)

The author describes a new, one-leaf variety (var. *granitovii*) of *Allium karataviense* Rgl. obtained from the "Tshatkalskii Zapovednik" nature conservation area of the Western Tien-Shan Mountains. The synonymy and occurrences of *Sedum alberti* Rgl. and of *S. ewersii* Ledeb., inhabiting also the Western Tien-Shan are also clarified. *S. ewersii* var. *homophyllum* Praeg. is found to grow wild in that region; a new, round-leaf variety (var. *cyclophyllum*), occurring in the same area, is also described.

Im Sinne des zwischen den Universitäten von Budapest und Taschkent bestehenden Austauschvertrages ergab sich schon seit 1971 jedes Jahr eine Gelegenheit zur Durchführung einer Geländeuntersuchung für Universitätshörer in Mittelasien. Über die bisherigen botanischen Ergebnisse dieser sind einige Publikationen bereits erschienen (Kovács-Láng—Isépy 1972, Isépy—Mészáros-Draskovits 1974, Priszter—Isépy 1974). Vorliegend werden einige neue oder wenig bekannte Taxa aus der reichen Flora des westlichen Tienschan erörtert. In dieser I. Abhandlung werden unter 1—4. *Allium karataviense* und einige *Sedum*-Taxa besprochen. Verfasser spricht für die gegebene Hilfe den Herbarien zu Leningrad und Taschkent seinen besten Dank aus.

1. **Allium karataviense** Rgl. var. **granitovii** Priszter

Die von Regel im Jahre 1874 beschriebene schöne Zwiebelart *Allium karataviense* mit eigenartigem Habitus wird in den Gärten Europas schon seit langem als Zierpflanze kultiviert. Der niedrige Wuchs, die 2 (seltener 3) grossen, breiten, tief geaderten, bläulichgrünen und sitzenden Blätter, die oberirdische Blattscheide sowie der sich an der Spitze des niedrigen Schaftes entwickelnde einzige, von rosaweissen Blüten gebildete grosse Blütenstand charakterisieren diese Art.

Nordöstlich von Taschkent, im Gebiet des Tschatkalskij Zapowednik haben wir in 2000—2300 m Höhe seit 1971 auch mehrere Jahre hindurch diese Pflanzenart eingesammelt und ihre Zwiebel im Botanischen Garten der Eötvös-Loránd-Universität zu Budapest weitergezüchtet. Diese Pflanzen weichen jedoch von dem in den europäischen Gärten kultivierten und wohl-

Abb. 1. Allium karataviense Rgl. var. *granitovii* Priszter (ad nat. delin. A. Bucsi)

bekannten zweiblättrigen Typ darin ab, dass sie lediglich ein einziges, gut entwickeltes Blatt hervorgebracht haben. Nicht nur die gepressten Exemplare aus dem Tienschan, sondern auch die in Blumentöpfen untergebrachten waren jährlich zurückkehrend einblättrig. (Und zwar nicht die unentwickelten Jungpflanzen, sondern die blühenden Individuen.)

Pflanzenarten mit einem einzigen Blatt kommen ziemlich selten vor. In der Familie der *Liliaceae* gibt es jedoch mehrere Beispiele hierfür. So bringen z. B. ein einziges Laubblatt — fast ständig — die in Portugal heimischen *Ornithogalum unifolium* (L.) Ker-Gawl. und *Scilla monophyllos* Link, *Muscari latifolium* J. Kirk aus Kleinasien oder *Allium unifolium* Kellogg hervor. Auch

unter den mittelasiatischen *Allium*-Arten gibt es mehere einblättrige, wie z. B. *A. monophyllum* Vved., *A. sergii* Vved., *A. eugenii* Vved. oder *A. alexeianum* Rgl.

Aufgrund des Gesagten halten wir die im westlichen Tienschan gesammelte einblättrige *Allium karataviense* für eine neue Varietät (cf. PRISZTER in Bot. Közlem. 1974 p. 59) und benennen sie zu Ehren des Professors der Botanik an der Universität zu Taschkent als var. *granitovii* (Abb. 1). Dieselbe Varietät fanden wir auch im Herbar des leningrader KOMAROW-Institutes.

Allium karataviense Rgl. var. **granitovii** Priszter, var. nova

A typo — florendi tempore — folio unico (30—40 cm longo et 6—8 cm lato) bene differt. Habitat in rupestribus Tien-Schan Occidentalis, territorio protectionis naturae Tschatkalskij Zapovednik dicto, 2000—2300 m.s.m. Specimen descriptum in herb. Horti Botanici Universitatis Budapestiensis conservatur. Legit I. ISÉPY, 5, 5. 1971. Ad honorem professoris Universitatis Taschkent I. I. GRANITOV denominatum.

Exemplum alterum in monte Ak-Tasch ab I. G. LEVITSCHEV et L. S. KRASOVSKAJA 25. 5. 1975 lectum in herbario laboratorii stationis Tschatkalskij Zapovednik vidi. — Specimina exsiccata in Herbario Academiae Scientiarum Instituti V. L. KOMAROV (Leningrad) visa:
1. Margilan prope Fergana; leg. N. DESSIATOFF, 1913;
2. Schachimardan, Alajskij Hrebet; leg. V. DROBOV, 1916;
3. ad rivum Kara Artscha, Kirgizskij Hrebet; leg. R. KAMELIN, 1969.

2. Sedum alberti Rgl.

In Mittelasien ist die von REGEL beschriebene Art *Sedum alberti* ziemlich verbreitet. Auch im umfangreichen Herbarium der Universität zu Taschkent enthält aus dem Tienschan von dieser Art eine sehr reiche Kollektion. Trotzdem ist diese Art in der Fachliteratur ziemlich konfundiert und in der europäischen Kultur fast unbekannt. Meine eigenen Erfahrungen haben mich schon seit Jahren davon überzeugt, dass diese Art auch in Mitteleuropa leicht gezüchtet werden kann.

Es gibt nur wenige weissblütige perennierende *Sedum*-Arten (die meisten haben nämlich gelbe Blüten). Der Grossteil der weissblütigen *Sedum*s gehören zu *S. album* L. agg., wie z. B. *S. athoum* DC., *S. micranthum* Bast., *S. balticum* Hartm., *S. clusianum* Guss., *S. serpentini* Janch., *S. brevifolium* DC. (Abb. 2. c) oder *S. gypsicolum* Boiss. et Reut. (Abb. 2. b). Alle diese Taxa sind durch die stumpfe Blattspitze charakterisiert. Das kaukasische und kleinasiatische *S. subulatum* (C. A. M.) Boiss. (syn.: *S. acutifolium* Ledeb.; Abb. 2. e) ähnelt sich der Art *S. album*, hat jedoch zugespitzte Blätter. Die bisher erwähnten Taxa sind alle von mittlerem Wuchs und der Grund ihrer Blätter ist nicht spornförmig. Von diesen weicht die niedrige (5—6 cm), dichtrasige Art *S.*

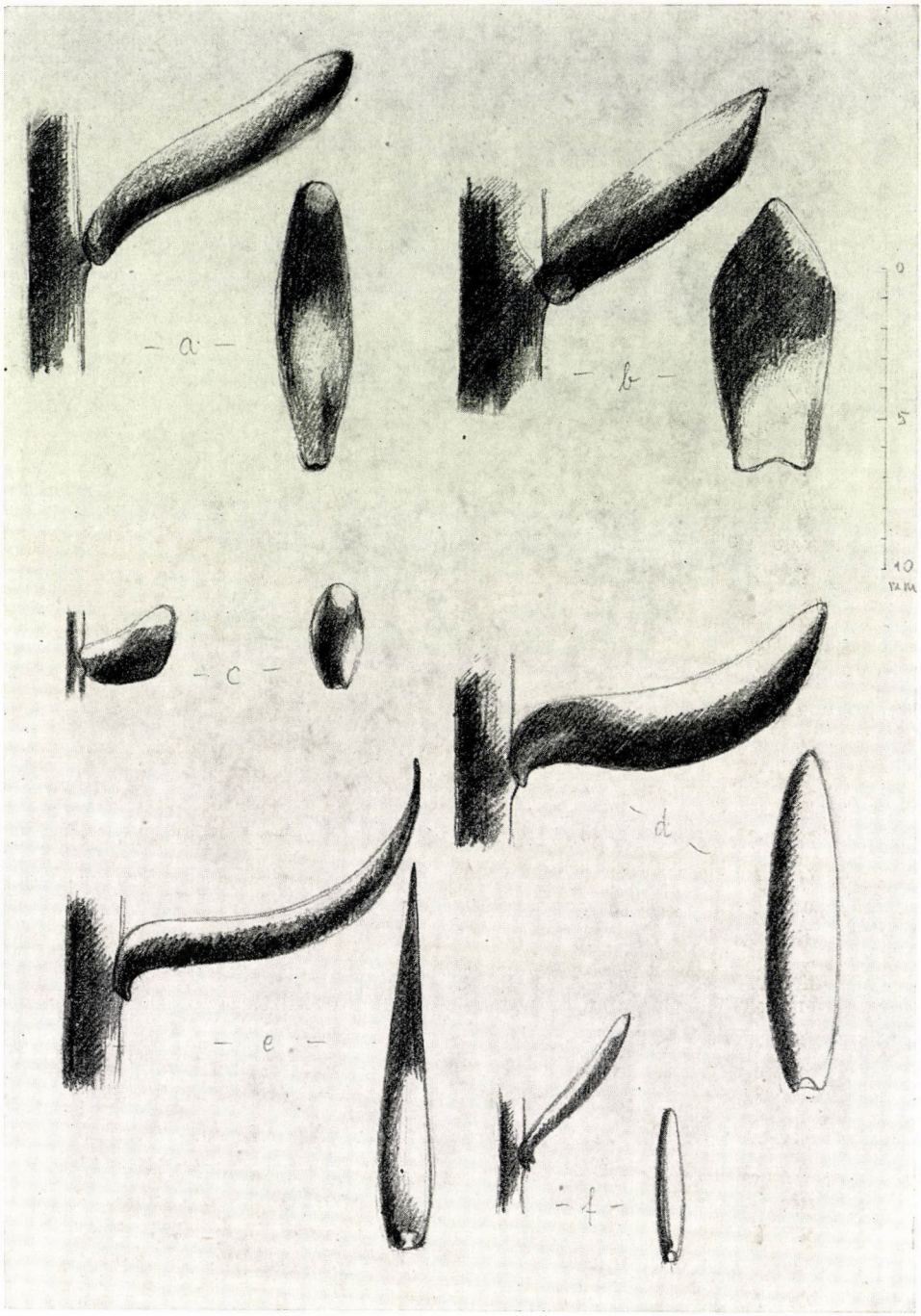

Abb. 2. Laubblätter einiger weissblühender *Sedum*-Arten. (Zeichnungen von A. PRISZTER) a: *Sedum album* L.; b: *S. gypsicolum* Boiss. et Reut.; c: *S. brevifolium* DC.; d: *S. alberti* Rgl.; e: *S. subulatum* (C. A. M.) Boiss.; f: *S. gracile* C. A. M.

gracile C. A. M. (Abb. 2. f) ab, deren dünne Blätter an der Basis — vielen anderen, jedoch gelbblütigen *Sedum*-Arten ähnlich — einen winzigen Sporn tragen, der sich dem Stengel anschmiegt. Eine solche sporntragende, weissblütige mittelasiatische Art stellt auch *S. alberti* Rgl. dar (Abb. 2. d), jedoch ist diese viel grösser (10—15 cm) als *S. gracile*, und die Blattspitze ist ebenso abgerundet wie die bei *S. album* (Abb. 2. a). Dem Habitus nach erinnert auch *S. alberti* an *S. album*, jedoch weicht sie von dieser letzteren vor allem durch den Sporn der Blätter, ferner durch ihre geographische Isolation ab.

Zu der Beschreibung von *S. alberti* in Gartenflora (1880) fügte REGEL auch eine gute Abbildung bei. Es ist überraschend, dass der hervorragende *Sedum*- und *Sempervivum*-Monograph L. PRAEGER diese REGELsche Pflanze völlig verkannt hat. PRAEGER brachte nämlich unter dem Namen *S. alberti* (1921 p. 191) eine mit der Art *S. gracile* fast völlig übereinstimmende Pflanzenzeichnung, mit der Bemerkung, dass "the plant illustrated in Gartenflora (tab. 1019, fig. 2) as *S. alberti* is a totally different thing". Diese Bemerkung stimmt an sich zwar völlig, doch war gerade PRAEGER derjenige, der die Pflanze von REGEL mit *S. gracile* verwechselte, so wie darauf bereits KOMAROV (1939), BERGER (1932) und FRÖDERSTRÖM (1932) gleichfalls hingewiesen hatten. Letzterer versah die in Kirgisien zuerst von SCHRENK gesammelte und als *Umbilicus affinis* beschriebene Pflanze mit einem neuen Namen (*Sedum schrenkii* Fröd.), was jedoch überflüssig war.

Die Synonymik der im Tienschan häufig vorkommenden Art *S. alberti* Rgl. ist also die folgende:

Umbilicus affinis Schrenk ex Fisch. et Mey. 1841
Sedum alberti Regel 1879, non Praeger 1921 (Quod est: *S. gracile* C. A. M.)
Cotyledon affinis (Schrenk) Maxim. 1883
Sedum affine (Schrenk) Hamet 1929, non Boreau 1866 (Quod est: *S. telephium* L. ssp. *complanatum* Gilib. var. *buxicolum* R. et C.)
Pseudosedum affine (Schrenk) Berger 1930
Sedum schrenkii Fröderström 1932.

3. **Sedum ewersii** Ledeb. var. **homophyllum** Praeg.

S. ewersii ist eine in Mittelasien weitverbreitete Art, die auch in den Gärten Mitteleuropas wohlbekannt ist, da sie wegen ihrer schönen Blüten, ihres niedrigen Wuchses von jeher eine beliebte Steingartenpflanze ist. Aus ihrem Formenkreis war uns bisher nur soviel bekannt, dass PRAEGER (1921 p. 96—99) aus einer Gartenkultur ihre kleinblättrige Zwergform unter dem Namen var. *homophyllum* Praeg. beschrieben und dargestellt hat. Der Beschreibung nach ist diese Varietät nur 5—8 cm hoch, die sterilen Triebe sind kaum kleiner als die fertilen, die Internodien sind kurz (0,3—0,5 cm), die Blätter nicht

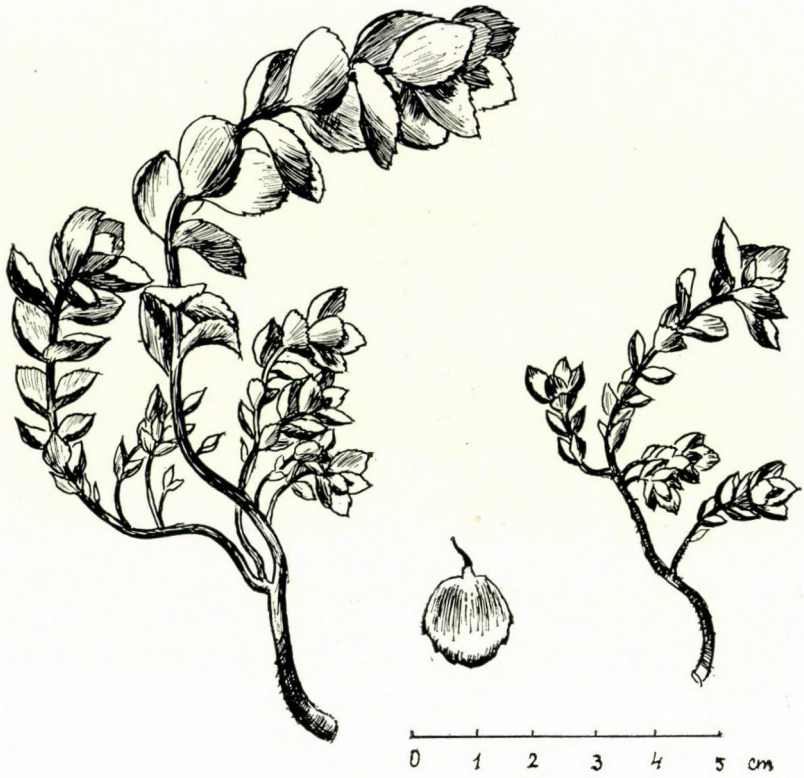

Abb. 3. Sedum ewersii Ledeb. var. *homophyllum* Praeg. (ad nat. delin. A. Bucsi)

stengelumfassend, sondern am Grunde keilförmig, ihr Rand ist rötlich, ihre Länge beträgt 1,3—1,8, ihre Breite 0,8—1,3 cm. Der Blütenstand ist dicht und klein (Abb. 3). Demgegenüber beträgt die Länge der fertilen Triebe des Typs 15—30 cm, die der Internodien 2—2,5 cm, ihre Blätter sind oval, am Grunde herzförmig und bedeutend stengelumfassend, 2—3 cm lang und 2 cm breit, der Blütenstand ist locker und grösser (Abb. 4).

Im Herbarium von Taschkent — für die Freundlichkeit der Kollegen T. A. Adilov und M. M. Nabiev auch an dieser Stelle dankend — fand ich zwischen den Exemplaren der Art *S. ewersii* in ziemlich grosser Menge die var. *homophyllum* vor. Dieselbe sah ich auch im Herbarium von Leningrad. So war einerseits die Behauptung (Fröderström 1930 p. 60) widerlegt, dass die var. *homophyllum* Praeger nur eine in Gärten vorkommende Varietät ist, da ja sie auch wild vielerorts vorkommt, andrerseits bereicherte sich die mittelasiatische Flora mit einem neuen Taxon. Die Synonymik des Typs und der Varietät sowie ihre Verbreitung ist die folgende:

S. ewersii Ledeb. (Syn.: *S. altaicum* Steph.)

var. *ewersii*: Westlicher Himalaja, Altai, Mittlerer und Westlicher

Abb. 4. Sedum ewersii Ledeb. var. *ewersii* (ad nat. delin. A. Bucsi)

Abb. 5. Sedum ewersii Ledeb. var. *cyclophyllum* Priszter (ad nat. delin. A. Bucsi)

Tienschan, Tibet, Dschungarei, Westmongolei, Pamir-Alai, Kirgisien;
var. *homophyllum* Praeg. (syn.: var. *turkestanicum* hort., *S. cyaneum* hort., non Rudolph): Ostkazachstan (z. B. Ustj-Kamenogorsk, Tarbagataj, Dschungarskij-Alatau), Ostkirgisien (Przewalsk, Talas); Ostusbekistan (Andischan, Fergana); Tadschikistan (Kara-Kul, Ostpamir).

4. **Sedum ewersii** Ledeb. var. **cyclophyllum** Priszter

Im Botanischen Garten der usbekischen Akademie der Wissenschaften zu Taschkent — und seit 1972 auch im Botanischen Garten der Budapester Universität — wird aus dem Tienschan stammendes solches *S. ewersii* kultiviert, das sich mit der Blattfarbe, vor allem mit der besonderen Blattform hervorhebt: seine Stengelblätter sind kürzer als die des Typs, sind nicht oval, sondern beinahe kreisförmig, ihre Farbe ist nicht bläulichgrün, sondern gelblichgrün, ihr Rand rötlich (Abb. 5). Diese, im Vergleich zu dem Typ etwas niedrigere Pflanze mit konstant abweichender Blattform sondern wir als eine neue Varietät ab:

Sedum ewersii Ledeb. var. **cyclophyllum** Priszter, var. nova

A typo (var. *ewersii*) foliis rotundis, brevioribus flavovirentibusque differt. Folia caulis medii 2—2,5 cm longa et lata, amplexicaulia, flavoviridia, margine rubro cincta. Habitu typo parum humilior (12—15 cm). Crescit in Tien-Schan Occidentali. Specimen descriptum — anno 1971 ex horto botanico Academiae Scientiarum, Taschkent orta — in herbario Horti Botanici Universitatis Budapestinensis conservatur. Legit Sz. Priszter 18. 5. 1973.

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2. Fergana; leg. D. Litvinov, 1895;
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REGEL, E. (1879): Sedum alberti Rgl. Acti Horti Petropol. **6/2,** 299; Gartenflora **29.** (1880), 227—228. tab. 1019. no. 2.

VVEDENSKY, A. I. (red., 1972, 1974): Conspectus Florae Asiae Mediae. Taschkent **2,** 82; **4,** 224—225.

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A DIAGNOSTIC KEY FOR THE IDENTIFICATION OF "SPECIES" OF STREPTOMYCES AND STREPTOVERTICILLIUM INCLUDED IN THE INTERNATIONAL STREPTOMYCES PROJECT

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An identification key for 414 "species" of *Streptomyces* and *Streptoverticillium* included in the ISP is presented. This dichotomous key is based on the partly modified methods and criteria of ISP. The key may help streptomycetologists to select, from among authentic named organisms of culture collections, type or reference strains for simultaneous morphological-cultural and physiological comparisons with closely related unidentified cultures, which is the most expedient method for sufficiently narrow taxonomic identifications.

There is no doubt that in the present "fluid" state of actinomycete taxonomy the simultaneous comparison of an unknown strain with authentic named cultures of closely related species, on the basis of as many features as possible, is the most expedient method for a sufficiently narrow taxonomic identification. In 1963 SZABÓ and MARTON made the first attempt at elaborating a diagnostic key based exclusively upon the data of authentic named cultures of species of *Streptomyces* to facilitate the selection of relatively few, suitable authentic strains for simultaneous comparisons and identification with unknown strains. Using the information acquired from the ISP study, ARAI and MIKAMI (1969) published an identification key for antifungal antibiotic producing streptomycetes. In 1972 KÜSTER presented a simple diagnostic key for the classification and identification of 274 named species included in the ISP.

It must be kept in mind, however, when using these identification keys and evaluating the results of simultaneous comparisons between known and unknown strains that there exists a wide range of variation within the individual species. Although type strains can considerably help us in identifying unknown cultures, the population species concept advocated by COWAN (1970) seems to be more realistic in the taxonomy of streptomycetes than the type species concept traditionally used for describing bacterial species (cf. also SZABÓ and MARTON, 1962; 1964a; 1964b; FLOCKTON and CROSS, 1975).

Another problem is the availability of these keys for identification purposes. A new critical evaluation of criteria and procedures used in the characterization of type cultures has revealed that the ISP methods for reporting spore mass color, reverse color, and spore chain morphology need improvement (SZABÓ and MARTON, 1976). E.g., according to the data given in the ISP descriptions (SHIRLING and GOTTLIEB, 1968a; 1968b; 1969; 1972) from among the 426 classified strains 232 (54%) fall within the range delineated by one wheel of the TRESNER—BACKUS color wheels, while 194 strains (46%) fall into 2, 3 or even 4 different color series, respectively. Consequently, when preparing dichotomous keys for identification purposes, it is rather difficult to divide streptomycetes into large groups or subdivisions on the basis of their aerial mass color determined by using the TRESNER—BACKUS system. On the other hand, a precise spore mass color identification is, quite often, very difficult oving to interferences from the colored substrate mycelium and to the dependence of the aerial mass color on the thickness and density of the spore mass. A reevaluation of data given in the ISP descriptions has also indicated that the morphological category of Retinaculiaperti cannot be considered as a distinguishing character which may be used for preparing dichotomous keys (cf. also the 8th edition of the BERGEY's Manual, 1975). The large number of tests yielding doubtful results in carbon utilization experiments can also considerably hinder our efforts to construct keys working for all species included, consistently with the same sequences of characters.

The diagnostic key presented below is an attempt to use in every single case such a combination of characters and their sequence which may provide the relatively highest probability of a correct identification according to the descriptive criteria used.

Methods

The first step in the identification of new isolates or unidentified strains of *Streptomyces* or *Streptoverticillium* is their description using the minimum descriptive criteria (spore chain morphology, spore surface, color of aerial and substrate mycelia, color in medium, carbon utilization) and methods of ISP (SHIRLING and GOTTLIEB, 1966). The second step is the approximative taxonomic identification of the investigated and described strains using the key presented in this paper. Finally, a simultaneous comparison of the strains in question is necessary with the type or reference strain (or strains) of that (or those) species which shows the highest similarity to them on the basis of the minimum descriptive criteria. Type cultures are available in international culture collections.

Analysing, however, the ISP descriptions it was found that some methods of the ISP needed improvement. For the separation of strains according to their substrate mycelium color a new more complete system of color groups offered by us (SZABÓ and MARTON, 1976) was already used in the preparation of the presented key:

A) Types (color groups) of pigmentation of the substrate mycelium

1. Yellow-brown (Y-b): The color of the mycelium exhibits different hues of yellow and brown in all diagnostic culture media and in all periods of growth; these "yellow-brown" colors may be shaded by gray in all degrees, from almost colorless light gray through dirty white to black.

2. Y-b + red: On at least one diagnostic culture medium and in a certain period of growth, the mycelium produces red or pink endopigments to such an extent that both the yellow-brown ground color and the gray shade are entirely obscured and the mycelium becomes red. The red endopigments are not pH sensitive or they may change, in the case of a few strains, from red or pink to the yellow-brown ground color either with the addition of 0.05 *N* HCl or, more rarely, with the addition of 0.05 *N* NaOH (Y-b ↔ red).
3. Y-b + blue: Similar to No. 2 above, except that the endopigment is blue. This pigment is not a pH indicator.
4. Y-b + blue ↔ red: Similar to No. 2 above, except that the reverse mycelium pigment is a pH indicator changing from blue or blue-violet to red-violet or red.
5. Y-b + blue ↔ green: Similar to No. 2 above, except that the reverse mycelium pigment is a pH indicator changing from blue, grayish purple or violet to green or deep green.
6. Y-b + green: Similar to No. 2 above, except that the reverse mycelium pigment is green. This endopigment is not a pH indicator or, very rarely, Y-b ↔ green.
7. Y-b + green ↔ red: Similar to No. 2 above, except that the rererse mycelium pigment is a pH indicator changing from green, olive, bluish green or grayish olive to red, pink, reddish or purplish brown.
8. Y-b + red + green: Two different, a red and a green, distinctive pigments can cause colorization in the substrate mycelium depending on the composition of the diagnostic medium employed. Neither of them is a pH indicator.
9. Y-b + red + blue: Similar to No. 8 above, except that the yellow-brown ground color of the substrate mycelium may be modified to red and/or to blue on the diagnostic media. These pigments are not pH sensitive.
10. Y-b + blue + green: Similar to No. 8 above, except that the color of substrate mycelium may be modified to blue and/or to green on the diagnostic media. These pigments are not pH sensitive.
11. Y-b + green + blue ↔ red: Similar to No. 8 above, except that the color of the substrate mycelium may be modified to green and/or to red, violet or blue depending on the composition and pH of the media. The green pigment is not pH sensitive.

B) Morphological sections used in the key

1. Rectiflexibiles (Rectus-flexibilis)
   Straight to flexuous spore chains
2. Spirals (Spira)
   Spiral spore chains: short, gnarled, or compact spirals; extended, long and open spirals; open loops, hooks or primitive spirals of wide diameter.
3. Verticillus-Rectus-flexibilis
   Verticillate, straight to flexuous
4. Verticillus-Spira
   Verticillate, spirals

The identification key

The dichotomous key presented below is constructed for the classification and identification of 414 named taxa included in the ISP and based on the ISP descriptions of type or reference strains. In consequence of the great number of doubtful results in carbon utilization tests and/or for lack of certain morphological or cultural diagnostic features the type strains of 43 "species" are not included in the key. The nomenclature, regarding the generic names and specific epithets, is identical with that of the ISP descriptions. Abbreviations used: **Act. = Actinomyces; St. = Streptomyces; Stv. = Streptoverticillium.**

Certain species included in the key are designated with an asterisk. It indicates that when studying the type or reference strains of these species the opinions of ISP workers differed concerning their one or two diagnostic

features which were, however, used by us in constructing the key for their identification. Consequently, the position of these species or, more exactly, that of their type strains in the key is questionable to a certain extent.

Two or more very similar or even identical type or reference strains designated with different specific epithets may be considered as a "distinct group". The individual groups were named mostly with the specific epithet of the oldest known species belonging to the group in question. Presumedly the members of the same group are representatives of a true species.

1. a. Verticil formation; spore surface smooth or smooth and/or warty **2**
b. No verticils produced; spore surface smooth, smooth and/or warty, spiny or hairy **28**
2. a. Sporophores in spirals **3**
b. Sporophores straight or wavy **5**
3. a. D-Glucose, L-arabinose, D-xylose, D-fructose, rhamnose, sucrose, raffinose, i-inositol, and D-mannitol are all utilized for growth
St. pallidus Reusser. ISP 5531
b. No growth with L-arabinose, sucrose, D-xylose, D-mannitol, rhamnose and raffinose **4**
4. a. Mature spore chains generally 10 to 20 spores per chain
Stv. netropsis (Finlay, Hochstein, Sobin, and Murphy) Baldacci, Farina, and Locci. ISP 5259
b. Mature spore chains generally 10 to 50 spores per chain
St. flavopersicus Oliver, Goldstein, Bower, Holper, and Otto. ISP 5093
5. a. Color of substrate mycelium: Y-b + blue ↔ red
Act. biverticillatus Preobrazhenskaya. ISP 5272
b. Color of substrate mycelium different **6**
6. a. Color of substrate mycelium: Y-b **7**
b. Color of substrate mycelium: Y-b + red **22**
7. a. Melanoid pigments are not produced in peptone-yeast-iron agar **8**
b. Melanoid pigments are produced in peptone-yeast-iron agar .. **13**
8. a. Poor growth on all carbon sources including D-glucose
Stv. cinnamoneum (Benedict, Dvonch, Shotwell, Pridham, and Lindenfelser) Baldacci, Farina, and Locci. ISP 5005
b. D-Glucose is utilized for growth **9**
9. a. No growth on i-inositol
Stv. orinoci Cassinelli, Grein, Orezzi, Pennella, and Sanfilippo. ISP 5571
b. i-Inositol is utilized for growth **10**
10. a. Sporulating aerial mycelium red or reddish

St. hachijoensis Yamaguchi. ISP 5114

b. Sporulating aerial mycelium gray or yellow to greenish-yellow **11**

11. a. Yellowish to greenish yellow pigment in the diagnostic media
St. luteoreticuli Katoh and Arai. ISP 5509

b. No pigment in the diagnostic media **12**

12. a. No growth or only trace of growth with raffinose
St. aspergilloides Rao, Marsh, and Renn. ISP 5565

b. Raffinose is utilized for growth
St. moro-okaensis Niida, Hamamoto, Tsuruoka, and Hara. ISP 5503

13. a. Sporulating aerial mycelium without reddish shade **14**

b. Sporulating aerial mycelium red or reddish **17**

14. a. Sporulating aerial mycelium white; melanoid pigments not formed in tyrosine agar
Stv. olivoreticuli (Arai, Nakada, and Suzuki) Baldacci, Farina, and Locci. ISP 5105

b. Sporulating aerial mycelium gray, green or yellow **15**

15. a. L-Arabinose is utilized for growth
St. blastmyceticus Watanabe, Tanaka, Fukuhara, Miyairi, Yonehara, and Umezawa. ISP 5029;
St. caespitosus* Sugawara and Hata. ISP 5603

b. No growth or only trace of growth on L-arabinose **16**

16. a. Melanoid pigments formed in tyrosine agar
St. albireticuli Nakazawa. ISP 5051; **St. paucisporogenes*** Hagemann, Nominé, and Pénasse. ISP 5315

b. No soluble brown pigment in tyrosine agar
Stv. eurocidicum (Okami, Utahara, Nakamura, and Umezawa) Locci, Baldacci, and Petrolini Baldan. ISP 5604

17. a. Melanoid pigments formed in tyrosine agar **18**

b. No soluble brown pigment in tyrosine agar **19**

18. a. Sucrose is utilized for growth
St. kishiwadensis* Shinobu and Kayamura. ISP 5397

b. No growth with sucrose
St. luteoverticillatus Shinobu. ISP 5038
St. ehimensis Nakazawa. ISP 5253

19. a. Sucrose is utilized for growth
St. mashuensis Sawazaki, Suzuki, Nakamura, Kawasaki, Yamashita, Isono, Anzai, Serizawa, and Sekiyama. ISP 5221

b. No growth with sucrose **20**

20. a. D-Mannitol is utilized for growth
Stv. rubrireticuli (Waksman and Henrici) Baldacci. ISP 5464
b. No growth with D-mannitol **21**

21. a. Spore chains are generally short containing 3 to 10 or more spores per chain (Septatum group)
St. tropicalensis Gupta. ISP 5520; **Stv. septatum** Locci, Baldacci, and Petrolini Baldan. ISP 5577
b. Spore chains moderately long with 10—50 spores per chain
Stv. kentuchense (Barr and Carman) Baldacci, Farina, and Locci. ISP 5052

22. a. Melanoid pigments are produced in peptone-yeast-iron agar .. **24**
b. Melanoid pigments are not produced in peptone-yeast-iron agar **23**

23. a. No growth with i-inositol
Stv. ladakanus Hanka, Evans, Mason, and Dietz. ISP 5587
b. i-Inositol is utilized for growth
Stv. griseoverticillatum (Shinobu and Shimada) Locci, Baldacci, and Petrolini Baldan. ISP 5507

24. a. D-Fructose is utilized for growth **25**
b. No growth with D-fructose **26**

25. a. Yellow or red, not pH sensitive soluble pigment in yeast-malt and oatmeal agar **Act. rectiverticillatus** Krasil'nikov and Yuan. ISP 5436; **Stv. roseoverticillatum*** (Shinobu) Farina and Locci. ISP 5039
b. Pigments other than melanoids not formed
Stv. hiroshimense (Shinobu) Farina and Locci. ISP 5037

26. a. Melanoid pigments not produced in tyrosine agar
Act. aureoversales Yuan. ISP 5387
b. Melanoid pigments formed in tyrosine agar **27**

27. a. Red pigment in the diagnostic media is pH sensitive changing from brown to reddish brown with addition of 0.05 *N* NaOH and from brown to yellowish brown with 0.05 *N* HCl
St. lilacinus Nakazawa, Tanabe, Shibata, Miyake, and Takewaka. ISP 5254
b. Yellow to orange or reddish pigment in the media not pH sensitive
Stv. kashmirense (Gupta and Chopra) Locci, Baldacci, and Petrolini Baldan. ISP 5336

28. a. Sporophores straight to flexuous **29**
b. Sorophores form long or short, loose or compact and open or closed spirals or hooks and loops **102**

29. a. Pigmentation of the substrate mycelium: No distinctive pigments on the diagnostic media (Y-b) **30**

b. Y-b is modified by distinctive pigments **85**

30. a. Melanoid pigments not produced in peptone-yeast-iron agar .. **31**

b. Melanoid pigments formed in peptone-yeast-iron agar **63**

31. a. Melanoid pigments formed in tyrosine agar **32**

b. Melanoid pigments not produced in tyrosine agar **33**

32. a. L-Arabinose is utilized for growth

Act. badius Kudrina. ISP 5139

b. No growth with L-arabinose

St. griseus (Krainsky) Waksman and Henrici. ISP 5236; **St. ornatus** Calot and Cercós. ISP 5307

33. a. Spores spiny (Sometimes a few primitive spirals may also be seen; cf. **127. a.**)

St. macrosporeus Ettlinger, Corbaz, and Hütter. ISP 5096

b. Spores smooth or smooth and/or warty **34**

34. a. Sporulating aerial mycelium red or reddish on certain media **35**

b. Aerial mycelium not red or reddish **44**

35. a. i-Inositol is utilized for growth

St. capreolus Higgens. ISP 5225

b. No growth with i-inositol **36**

36. a. D-Mannitol is utilized for growth **37**

b. No growth with D-mannitol **40**

37. a. Sucrose is utilized for growth

St. somaliensis (Brumpt) Waksman and Henrici. ISP 5267

b. No growth with sucrose **38**

38. a. Rhamnose is utilized for growth **39**

b. No growth with rhamnose

St. sindenensis Nakazawa and Fujii. ISP 5255

39. a. Mature spore chains moderately short with 3 to 10, or sometimes more than 10, spores per chain

St. pluricolorescens Okami and Umezawa. ISP 5019

b. Mature spore chains contain 10 to 50 or more spores per chain

Act. rubiginosohelvolus Kudrina. ISP 5176

40. a. Raffinose is utilized for growth

St. exfoliatus (Waksman and Curtis) Waksman and Henrici. ISP 5060

b. No growth with raffinose **41**

41. a. L-Arabinose is utilized for growth **42**

b. No growth with L-arabinose **43**

42. a. Sucrose is utilized for growth
St. filamentosus Okami and Umezawa. ISP 5022
b. No growth with sucrose (Roseolus group)
St. roseosporus Falcão de Morais and Dália Maia. ISP 5122; **Act. roseolus** Preobrazhenskaya and Sveshnikova. ISP 5174

43. a. Mature spore chains short with 3 to 10, or sometimes more than 10, spores per chain
St. roseus (Krainsky) Pridham, Hesseltine, and Benedict. ISP 5076
b. Mature spore chains generally long and flexuous with 10 to 50 or often more than 50 spores per chain
St. termitum Duché, Heim, and Lavoureur. ISP 5329; **St. salmonicida** Rucker. ISP 5472

44. a. No growth with rhamnose **45**
b. Rhamnose is utilized for growth **53**

45. a. No growth with D-mannitol **46**
b. Mannitol is utilized for growth **48**

46. a. Sucrose is utilized for growth
St. avellaneus Baldacci and Grein. ISP 5554
b. No growth with sucrose **47**

47. a. D-Xylose is utilized for growth
St. aburaviensis Nishimura, Kimura, Tawara, Sasaki, etc. ISP 5033
b. No growth with D-xylose
St. galtieri Goret and Joubert. ISP 5350

48. a. i-Inositol is utilized for growth
St. alboniger* Porter, Hewitt, Hesseltine, Krupka, Lowery, Wallace, Bohonos, and Williams. ISP 5043
b. No growth with i-inositol **49**

49. a. Raffinose is utilized for growth
St. kanamyceticus Okami and Umezawa. ISP 5500
b. No growth with raffinose **50**

50. a. No growth with L-arabinose
Act. streptomycini Krasil'nikov. ISP 5200
b. L-Arabinose is utilized for growth **51**

51. a. Sucrose is utilized for growth
St. odorifer (Rullmann) Waksman. ISP 5347
b. No growth with sucrose **52**

52. a. Short spore chains containing generally 3 to 10 spores per chain
St. albidoflavus (Rossi-Doria) Waksman and Henrici. ISP 5455; **St. tetanusemus** (author?). ISP 5585

b. Long spore chains containing 10 to 50 or more spores per chain (Aerial mycelium yellow, greenish-yellow or yellowish-gray) (Ochroleucus group) **St. canescens*** Hickey, Corum, Hidy, Cohen, Nager, and Kropp. ISP 5001; **St. coriofaciens** (Schmidt-Thomé, Steigler, Fries, and Weidenmüller. ISP 5485; **St. felleus** Lindenbein. ISP 5130; **St. intermedius** (Krüger emend. Wollenweber) Waksman. ISP 5372; **St. krainskii*** (Duché) Pridham, Hesseltine, and Benedict. ISP 5321; **Act. levoris** Nikitina. ISP 5202; **St. limosus** Lindenbein. ISP 5131; **Act. ochroleucus** Neukirch. ISP 5591; **St. sampsonii** (Millard and Burr) Waksman. ISP 5394

53. a. No growth with L-arabinose **54**

b. L-Arabinose is utilized for growth **57**

54. a. D-Mannitol is utilized for growth **55**

b. No growth with D-mannitol **56**

55. a. 3 to 10 spores or more per chain **Act. cretaceus** (Krüger) Krasil'nikov. ISP 5561

b. 10 to 50 spores or more per chain **St. lipmanii** (Waksman and Curtis) Waksman and Henrici. ISP 5070; **St. acidoresistans.*** ISP 5540

56. a. No growth with sucrose **St. omiyaensis** Umezawa and Okami. ISP 5552

b. Sucrose is utilized for growth **St. gelaticus** (Waksman) Waksman and Henrici. ISP 5065

57. a. Sporulating aerial mycelium blue — at least in sectors — on salts-starch agar **St. orientalis** Pittenger and Brigham. ISP 5040

b. Sporulating aerial mycelium never blue **58**

58. a. Sucrose is utilized for growth **60**

b. No growth with sucrose **59**

59. a. No growth with D-mannitol **St. nitrosporeus** Okami. ISP 5023; **St. hydrogenans** Lindner, Junk, Nesemann, and Schmidt-Thomé. ISP 5586

b. D-Mannitol is utilized for growth; aerial mycelium white, yellow, yellowish-green, yellowish gray or gray (Parvus group) **Act. albovinaceus** Kudrina. ISP 5136; **St. alboviridis*** (Duché) Pridham, Hesseltine, and Benedict. ISP 5326; **Act. candidus** Krasil'nikov. ISP 5141; **St. chrysomallus** Lindenbein. ISP 5128; **Act. citreofluorescens** Korenyako, Krasil'nikov, Nikitina, and

Sokolova. ISP 5265; **St. flavogriseus** (Duché) Waksman. ISP 5323; **Act. fluorescens** Korenyako, Krasil'nikov, Nikitina, and Sokolova. ISP 5203; **Act. globisporus** Krasil'nikov. ISP 5199; **St. griseinus** Waksman. ISP 5047; **St. luteolutescens** (Yen) Pridham. ISP 5600; **St. nigrifaciens** Waksman. ISP 5071; **St. parvus** (Krainsky) Waksman and Henrici. ISP 5348; **St. saprophyticus*** nom. dub. ISP 5537; **St. setonii** (Millard and Burr) Waksman. ISP 5395; **Act. vulgaris** Nikitina, Korenyako, and Krasil'nikov. ISP 5201; **St. willmorei** (Erikson) Waksman and Henrici. ISP 5459

60. a. No growth with i-inositol **61**

b. i-Inositol is utilized for growth **62**

61. a. Mature spore chains short with 3 to 10, or sometimes more than 10, spores per chain

St. griseolus* (Waksman) Waksman and Henrici. ISP 5067

b. Spore chains longer (10 to 50 or more spores)

St. albidus* (Duché) Waksman. ISP 5320; **Act. oligocarbophilus*** (Beijerinck and van Delden) Lantzsch. ISP 5589; **St. microflavus*** (Krainsky) Waksman and Henrici. ISP 5331

62. a. Sporulating aerial mycelium gray

Act. atroolivaceus* Preobrazhenskaya, Blinov, and Ryabova. ISP 5137; **St. alni*** (Woronin) Fiuczek. ISP 5557; **St. viridogenes*** Waksman. ISP 5454

b. Sporulating aerial mycelium white, yellow, yellowish- to greenish-gray to greenish-yellow; no growth with raffinose (Cellulosae group)

St. autotrophicus Takamiya and Tubaki. ISP 5011; **St. baarnensis** (Duché) Pridham, Hesseltine, and Benedict. ISP 5232; **St. cellulosae** (Krainsky) Waksman and Henrici. ISP 5362; **Act. griseoloalbus** Kudrina. ISP 5468

63. a. Sporulating aerial mycelium red or reddish at least on certain media **64**

b. Sporulating aerial mycelium not red or reddish **68**

64. a. i-Inositol is utilized for growth (Phaeochromogenes group)

St. lincolnensis Mason, Dietz, and De Boer. ISP 5355; **St. phaeochromogenes** (Conn) Waksman. ISP 5073; **St. roseogriseus** Routien. ISP 5488; **Act. umbrinus** Sveshnikova. ISP 5278

b. No growth with i-inositol **65**

65. a. D-Xylose is utilized for growth **66**

b. No growth with D-xylose **67**

66. a. Sucrose is utilized for growth (A few spore chains may terminate in spirals)

St. polychromogenus Hagemann, Pénasse, and Teillon. ISP 5316

b. No growth with sucrose

Act. roseoviridis Preobrazhenskaya. ISP 5175

67. a. No growth with D-fructose

St. xanthophaeus Lindenbein. ISP 5134

b. D-Fructose is utilized for growth

St. subrutilus Arai and Kuroda. ISP 5445; **Act. flavotricini** Preobrazhenskaya and Sveshnikova. ISP 5152

68. a. No growth with D-mannitol **69**

b. D-Mannitol is utilized for growth **73**

69. a. Raffinose is utilized for growth (Gardneri group)

St. gardneri (Waksman) Waksman. ISP 5064; **St. ostreogriseus** Whitfield et al. ISP 5511; **St. xanthocidicus** Asahi, Nagatsu, and Suzuki. ISP 5575

b. No growth with raffinose **70**

70. a. Rhamnose is utilized for growth (Flavochromogenes group)

St. flavochromogenes (Krainsky) Waksman and Henrici. ISP 5541; **St. venezuelae** Ehrlich, Gottlieb, Burkholder, Anderson, and Pridham. ISP 5230

b. No growth with rhamnose **71**

71. a. No growth with D-fructose

St. zaomyceticus Hinuma. ISP 5196; **St. albolongus** Tsukiura, Okanishi, Koshiyama, Ohmori, Miyaki, and Kawaguchi. ISP 5570

b. D-Fructose is utilized for growth **72**

72. a. Melanoid pigments not produced in tyrosine agar (Tanashiensis group)

St. purpeofuscus Yamaguchi and Saburi. ISP 5283; **St. tanashiensis** Hata, Ohki, and Higuchi. ISP 5195

b. Melanoid pigments formed in tyrosine agar

St. showdoensis Nishimura, Mayama, Komatsu, Kato, Shimaoka, and Tanaka. ISP 5504

73. a. Spore surface: Spiny (Some hooks or loops may be seen on yeast-malt agar or on oatmeal agar)

St. thermophilus (Gilbert) Waksman and Henrici. ISP 5365

b. Spore surface: Smooth **74**

74. a. Sporulating aerial mycelium gray **75**

b. Sporulating aerial mycelium yellow, greenish-yellow to grayish-yellow **80**

75. a. Melanoid pigments formed in tyrosine agar **76**

b. Melanoid pigments not produced in tyrosine agar

St. spadicis Bromer, Hoehn, and McGuire. ISP 5476

76. a. D-Xylose is utilized for growth **77**

b. No growth with D-xylose

St. achromogenes Okami and Umezawa. ISP 5028

77. a. D-Glucose, L-arabinose, D-xylose, D-fructose, rhamnose, sucrose, raffinose, i-inositol, and D-mannitol are all utilized for growth

St. actuosus Pinnert, Ninet, and Preud'homme. ISP 5337

b. No growth at least with one of the diagnostic carbon sources **78**

78. a. No growth with i-inositol (Immature aerial mycelium brownish, while the mature one dark gray)

St. bikiniensis* Johnstone and Waksman. ISP 5581

b. i-Inositol is utilized for growth **79**

79. a. No growth on sucrose and raffinose

St. antibioticus* (Waksman and Woodruff) Waksman and Henrici. ISP 5234

b. No growth with rhamnose

St. noboritoensis* Isono, Yamashita, Tomiyama, and Suzuki. ISP 5223.

80. a. i-Inositol is utilized for growth **83**

b. No growth with i-inositol **81**

81. a. Rhamnose is utilized for growth

Act. cyaneofuscatus Kudrina. ISP 5148

b. No growth with rhamnose **82**

82. a. L-Arabinose is utilized for growth

St. cavourensis Giolitti. ISP 5300

b. No growth with L-arabinose (Griseobrunneus group)

St. bacillaris (Krasil'nikov) Pridham. ISP 5598; **St. griseobrunneus** (Waksman) Waksman. ISP 5066

83. a. L-Arabinose is utilized for growth **84**

b. No growth with L-arabinose

St. michiganensis Corbaz, Ettlinger, Keller-Schierlein, and Zähner. ISP 5015

84. a. No growth with raffinose

St. gougeroti* (Duché) Waksman and Henrici. ISP 5324

b. Raffinose is utilized for growth

Act. aureomonopodiales Krasil'nikov and Yuan. ISP 5416; **St. flavofungini** Uri and Békési. ISP 5366; **St. xanthochromogenus*** Arishima, Sakamoto, and Sato. ISP 5111

85. a. Color of substrate mycelium: Y-b + blue ↔ green

St. caeruleus (Baldacci) Pridham, Hesseltine, and Benedict. ISP 5103

b. Color of substrate mycelium different **86**

86. a. Color of substrate mycelium: Y-b + red ↔ green

St. herbaricolor Kawato and Shinobu. ISP 5123

b. Color of substrate mycelium different **87**

87. a. Color of substrate mycelium: Y-b + blue ↔ red **88**

b. Color of substrate mycelium different **89**

88. a. Melanoid pigments are produced in peptone-yeast-iron agar

St. cinereoruber Corbaz, Ettlinger, Keller-Schierlein, and Zähner. ISP 5012; **St. indigoferus** Shinobu and Kawato. ISP 5124; **Act. violaceorectus** Ryabova and Preobrazhenskaya. ISP 5279

b. Melanoid pigments are not produced in peptone-yeast-iron agar

St. californicus (Waksman and Curtis) Waksman and Henrici. ISP 5058; **St. puniceus** Finlay and Sobin. ISP 5083

89. a. Color of substrate mycelium: Y-b + red **90**

b. Color of substrate mycelium: Y-b + green **98**

90. a. Mature spore chains generally 3 to 10 spores per chain **91**

b. Spore chains 10 to 50 or more spores per chain **92**

91. a. No growth with raffinose; L-arabinose is utilized for growth

St. griseoluteus Umezawa, Hayano, Maeda, Ogata, and Okami. ISP 5392

b. Raffinose utilized for growth; no growth with L-arabinose

St. ramulosus Ettlinger, Gäumann, Hütter, Keller-Schierlein, Kradolfer, Neipp, Prelog, and Zähner. ISP 5100

92. a. Melanoid pigments are produced in peptone-yeast-iron agar .. **93**

b. Melanoid pigments are not produced in peptone-yeast-iron agar **94**

93. a. Melanoid pigments not produced in tyrosine agar

St. fulvissimus (Jensen) Waksman and Henrici. ISP 5593; **St. spectabilis** Dietz. ISP 5512

b. Melanoid pigments formed in tyrosine agar (Phaeopurpureus group)

St. melanogenes Sugawara and Onuma. ISP 5192; **St. phaeoviridis** Shinobu. ISP 5285; **St. phaeopurpureus**

Shinobu. ISP 5125

94. a. D-Glucose, L-arabinose, D-xylose, D-fructose, rhamnose, sucrose, raffinose, i-inositol and D-mannitol are all utilized for growth
St. moderatus Reusser. ISP 5529; **Act. prunicolor*** Ryabova and Preobrazhenskaya. ISP 5335

b. Not all carbon sources are utilized **95**

95. a. No growth with D-xylose **St. misakiensis** Nakamura. ISP 5222

b. D-Xylose is utilized for growth **96**

96. a. No growth with rhamnose
St. vinaceus (Mayer, Crane, De Boer, Konopka, Marsh, and Eisman) Waksman. ISP 5257

b. Rhamnose is utilized for growth **97**

97. a. No growth with D-mannitol
Act. roseofulvus Preobrazhenskaya. ISP 5172

b. D-Mannitol is utilized for growth
St. finicarius (Duché) Waksman and Henrici. ISP 5322

98. a. No growth with D-xylose
St. gedanensis (Scheele and Petruschky 1897 or Löhlein 1909) Waksman. ISP 5518

b. D-Xylose is utilized for growth **99**

99. a. Color of aerial mycelium: Yellow; no growth with rhamnose (Brown substrate mycelium pigment on oatmeal agar is pH sensitive changing from brown to green with addition of 0.05 *N* NaOH)
St. coelicolor (Müller) Kutzner and Waksman. ISP 5233

b. Color of aerial mycelium: Gray; rhamnose is utilized for growth **100**

100. a. No growth with D-fructose
St. flavovirens (Waksman) Waksman and Henrici. ISP 5062

b. D-Fructose is utilized for growth **101**

101. a. Spore chains short with 3 to 10 spores per chain
St. scabies (Thaxter) Waksman and Henrici. ISP 5078

b. Spore chains with 10 to 50 spores per chain
Act. fulvoviridis Kuchaeva, Krasil'nikov, Skryabin, and Taptikova. ISP 5210

102. a. Spore surface: Smooth or smooth and/or warty **157**

b. Spore surface spiny or hairy[1] **103**

[1] Spiny or hairy spore surface may be combined with warty surface ornamentation or sometimes smooth spores may also occur among the spiny or hairy ones. We do not consider these particular types or combinations of types as separate categories of surface ornamentation available for species differentiation.

103. a. Spore surface: Spiny **104**
b. Spore surface: Hairy (or hairy to spiny) **143**
104. a. Color of substrate mycelium: Y-b **105**
b. Color of substrate mycelium different **129**
105. a. Melanoid pigments produced in peptone-yeast-iron agar **106**
b. Melanoid pigments not produced in peptone-yeast-iron agar .. **118**
106. a. Melanoid pigments not produced in tyrosine agar **107**
b. Melanoid pigments formed in tyrosine agar **111**
107. a. Sporulating aerial mycelium red or reddish at least on certain media (Janthinus group)
Act. janthinus Artamonova and Krasil'nikov. ISP 5206; **St. thermotolerans** Pagano, Donovick, Dutcher, and Heuser. ISP 5227
b. Sporulating aerial mycelium not red or reddish **108**
108. a. Sporulating aerial mycelium blue or bluish at least on certain media (Chartreusis group)
St. chartreusis Calhoun and Johnson. ISP 5085; **Act. coerulescens*** Preobrazhenskaya. ISP 5146
b. Sporulating aerial mycelium not blue or bluish **109**
109. a. Sporulating aerial mycelium gray
Act. chromofuscus Preobrazhenskaya, Ryabova, and Blinov. ISP 5273
b. Sporulating aerial mycelium white, yellow to grayish-yellow .. **110**
110. a. No growth with L-arabinose, sucrose, raffinose, rhamnose, and i-inositol **St. roseochromogenus** (Jensen) Waksman and Henrici. ISP 5463
b. L-Arabinose, sucrose, raffinose, rhamnose and i-inositol are utilized for growth **St. hawaiiensis*** Cron, Whitehead, Hooper, Heinemann, and Lein. ISP 5042
111. a. Sporulating aerial mycelium red or reddish at least on certain media **112**
b. Sporulating aerial mycelium not red or reddish **115**
112. a. No growth with rhamnose **113**
b. Rhamnose is utilized for growth **114**
113. a. No growth with D-mannitol
Act. violascens Preobrazhenskaya and Sveshnikova. ISP 5183
b. D-Mannitol is utilized for growth (Durhamensis group)
St. durhamensis Gordon and Lapa. ISP 5539; **St. alanosinicus** Thiemann and Beretta. ISP 5606
114. a. No growth with sucrose
St. yokosukanensis Nakamura. ISP 5224

b. Sucrose is utilized for growth (Longisporus group)
St. arenae Pridham, Hesseltine, and Benedict. ISP 5293; **St. cellostaticus** Hamada. ISP 5189; **Act. longisporus** Krasil'nikov. ISP 5166

115. a. No growth with rhamnose **116**
b. Rhamnose is utilized for growth **117**

116. a. No growth with raffinose; sporulating aerial mycelium blue
St. curacoi Cataldi. ISP 5107
b. Raffinose is utilized for growth; sporulating aerial mycelium gray (Filipinensis group)
St. griseochromogenes Fukunaga, Misato, Ishii, and Asakawa. ISP 5499; **St. filipinensis** Ammann, Gottlieb, Brock, Carter, and Whitfield. ISP 5112

117. a. Sporulating aerial mycelium is blue at least on certain media (Bicolor group) **St. afghaniensis** Shimo, Shiga, Tomosugi, and Kamoi. ISP 5228; **Act. bicolor** Preobrazhenskaya. ISP 5140; **St. lanatus** Frommer. ISP 5090; **St. peruviensis** (anonymous). ISP 5592
b. Sporulating aerial mycelium is brownish-gray, grayish yellowish brown **St. gannmycicus** Hosoya and Soeda. ISP 5572

118. a. Sporulating aerial mycelium is red or reddish at least on certain media **119**
b. Aerial mycelium not red or reddish **122**

119. a. L-Arabinose is utilized for growth **120**
b. No growth with L-arabinose **121**

120. a. Raffinose is utilized for growth
Act. malachiticus Preobrazhenskaya and Ryabova. ISP 5167
b. No growth with raffinose (Variabilis group)
St. arabicus Shibata, Nakazawa, Miyake, Inoue, and Okabori. ISP 5252; **St. erythrogriseus** Falcão de Morais and Dália Maia. ISP 5116; **Act. variabilis** Preobrazhenskaya, Ryabova, and Blinov. ISP 5179

121. a. Raffinose is utilized for growth
St. fasiculatus Pittenger and Nelms. ISP 5054; **St. natalensis*** Struyk, Hoette, Drost, Waisvisz, Van Eek, and Hoogerheide. ISP 5357
b. No growth with raffinose **St. albulus** Routien. ISP 5492

122. a. Sporulating aerial mycelium is blue or bluish on certain media
St. bluensis Mason, Dietz, and Hanka. ISP 5564
b. Aerial mycelium not blue **123**

123. a. Sporulating aerial mycelium is green or greenish on certain media

..... **124**

b. Aerial mycelium not green **125**

124. a. Mature spore chains short with 3 to 10, or sometimes more than 10 spores per chain

St. prasinus Ettlinger, Corbaz, and Hütter. ISP 5099

b. Spore chains generally 10 to 30 spores per chain

St. hirsutus Ettlinger, Corbaz, and Hütter. ISP 5095

125. a. No growth with rhamnose **126**

b. Rhamnose is utilized for growth **127**

126. a. No growth with L-arabinose; raffinose is utilized; aerial mycelium pale yellow or white

St. chattanoogensis Burns and Holtman. ISP 5002

b. L-Arabinose is utilized for growth; no growth with raffinose; aerial mycelium gray

St. toyocaensis Nishimura, Katagiri, Sato, Mayama, and Shimaoka. ISP 5030

127. a. Mature spore chains with 3 to 10 or sometimes more than 10 spores per chain **St. craterifer** (Millard and Burr) Waksman. ISP 5296; **Act. griseorubens** Preobrazhenskaya, Blinov, and Ryabova. ISP 5160; **St. macrosporeus** Ettlinger, Corbaz, and Hütter. ISP 5096

b. Spore chains with 10 to 50 or sometimes more than 50 spores per chain **128**

128. a. No growth with raffinose (Griseoflavus group)

St. albaduncus Tsukiura, Okanishi, Ohmori, Koshiyama, Miyama, Miyaki, Kitazima, and Kawaguchi. ISP 5478; **St. griseoflavus** (Krainsky) Waksman and Henrici. ISP 5456; **St. lusitanus** Villax. ISP 5568; **Act. rubiginosus** Preobrazhenskaya, Blinov, and Ryabova. ISP 5177; **St. werraensis** Wallhäusser and Huber. ISP 5486

b. Raffinose is utilized for growth (presumedly all diagnostic carbon sources are utilized) (Antimycoticus group)

St. antimycoticus Waksman. ISP 5284; **St. canus*** Heinemann, Kaplan, Muir, and Hooper. ISP 5017; **St. saraceticus*** Berger, Goldberg, Sternbach, and Müller. ISP 5241; **St. sparsogenes** Owen, Dietz, and Camiener. ISP 5356; **Act. virido-diastaticus*** Baldacci, Grein, and Spalla. ISP 5249

129. a. Color of substrate mycelium: Y-b + blue ↔ red; melanoid pigment formed in peptone-yeast-iron agar; D-glucose, L-arabinose, sucrose, D-xylose, i-inositol, D-mannitol, D-fructose, rhamnose and raffinose

are all utilized for growth; color in medium: blue ↔ red (Violaceus group) **Act. coeliatus** Krasil'nikov, Sorokina, Alferova, and Bezzubenkova. ISP 5422; **Act. coerulatus** Krasil'nikov, Sorokina, Alferova, and Bezzubenkova. ISP 5424; **St. cyaneus** (Krasil'nikov) Waksman. ISP 5108; **Act. cyanoglomerus** subsp. **cellulosae** Krasil'nikov, Sorokina, Alferova, and Bezzubenkova. ISP 5427; **St. indigocolor** (Krasil'nikov, Sorokina, Alferova, and Bezzubenkova) Pridham. ISP 5432; **St. purpurascens** Lindenbein. ISP 5310; **Act. roseoviolaceus** Sveshnikova. ISP 5277; **St. violaceus** (Rossi-Doria) Waksman and Henrici. ISP 5082; **Act. violarus** Artamonova and Krasil'nikov. ISP 5205; **St. violatus** (Artamonova and Krasil'nikov) Pridham. ISP 5209

b. Color of substrate mycelium different **130**

130. a. Color of substrate mycelium: Y-b + bluish-green ↔ red **131**

b. Color of substrate mycelium different **132**

131. a. Melanoid pigments formed in peptone-yeast-iron agar **St. viridis** (Lombardo-Pellegrino) Waksman. ISP 5381

b. Melanoid pigments are not formed in peptone-yeast-iron agar **St. viridochromogenes** (Krainsky) Waksman and Henrici. ISP 5110.

132. a. Color of substrate mycelium: Y-b + red **133**

b. Color of substrate mycelium different **135**

133. a. No growth with raffinose **Act. griseoincarnatus** Preobrazhenskaya, Ryabova, and Blinov. ISP 5274; **St. matensis** Margalith, Beretta, and Timbal. ISP 5188

b. Raffinose is utilized for growth **134**

134. a. Short spore chains with 3 to 10 or more spores per chain **St. thermodiastaticus** (Bergey et al.) Waksman. ISP 5573

b. Moderately long spore chains of 10 to 50 or more spores per chain **Act. griseoruber** Ryabova and Preobrazhenskaya. ISP 5275; **St. erythraeus** (Waksman) Waksman and Henrici. ISP 5517

135. a. Color of substrate mycelium: Y-b + green **136**

b. Color of substrate mycelium different **139**

136. a. Melanoid pigments are not formed in peptone-yeast-iron agar **St. olivoviridis** Kuchaeva, Krasil'nikov, Skryabin,

and Taptykova. ISP 5211

b. Melanoid pigments produced in peptone-yeast-iron agar **137**

137. a. Melanoid pigments are not produced in tyrosine agar; D-glucose, L-arabinose, sucrose, D-xylose, i-inositol, D-mannitol, D-fructose, rhamnose and raffinose are all utilized for growth

St. iakyrus deQueiroz and Albert. ISP 5482

b. Melanoid pigments produced in tyrosine agar **138**

138. a. No growth with sucrose; raffinose is utilized

St. echinatus Corbaz, Ettlinger, Gäumann, Keller-Schierlein, Kradolfer, Neipp, Prelog, Reusser, and Zähner. ISP 5013

b. Sucrose is utilized; no growth with raffinose

Act. malachitorectus Preobrazhenskaya, Maximova, and Blinov. ISP 5333

139. a. Color of substrate mycelium: Y-b + green to blue (not pH ind.)

Act. cyanoalbus Krasil'nikov and Agre. ISP 5198

b. Color of substrate mycelium different **140**

140. a. Color of substrate mycelium: Y-b + green + red (Coeruleorubidus group) **Act. coeruleorubidus** Preobrazhenskaya. ISP 5145; **Act. coeruleofuscus** Preobrazhenskaya. ISP 5144; **St. steffisburgensis** subsp. **steffisburgensis** Dietz. ISP 5547

b. Color of substrate mycelium different **141**

141. a. Color of substrate mycelium: Y-b + green + blue; melanoid pigments are not produced in peptone-yeast-iron agar

Act. albocyaneus Krasil'nikov and Agre. ISP 5197

b. Color of substrate mycelium different; melanoid pigments are produced **142**

142. a. Color of substrate mycelium: Y-b + blue ↔ red + green

St. regalis Reusser. ISP 5532

b. Color of substrate mycelium: Y-b + red + blue

St. bellus Margalith and Beretta. ISP 5185

143. a. Color of substrate mycelium: Y-b **144**

b. Color of substrate mycelium different **152**

144. a. Melanoid pigments are produced in peptone-yeast-iron agar .. **145**

b. Melanoid pigments are not produced in peptone-yeast-iron agar **147**

145. a. No growth with rhamnose and i-inositol

St. lucensis Arcamone, Bertazzoli, Canevazzi, Di Marco, Ghione, and Grein. ISP 5317

b. Rhamnose and i-inositol are utilized for growth **146**

146. a. Aerial mycelium gray

St. pilosus Ettlinger, Corbaz, and Hütter. ISP 5097

b. Aerial mycelium gray but on certain media grayish olive, greenish gray or olive gray

St. prasinosporus Tresner, Hayes, and Backus. ISP 5506; **Act. flavoviridis** Krasil'nikov. ISP 5153

147. a. Only D-glucose is utilized for growth; color of aerial mycelium gray, greenish gray, pale blue, bluish gray

St. pactum Bhuyan, Dietz, and Smith. ISP 5530; **St. karnatakensis** Pinto and Ramasarma. ISP 5345

b. Carbon utilization pattern is different **148**

148. a. D-Glucose, L-arabinose, sucrose, D-xylose, i-inositol, D-mannitol, D-fructose, rhamnose and raffinose are utilized for growth; aerial mycelium gray **St. calvus** Backus, Tresner, and Campbell. ISP 5010

b. Not all diagnostic C-sources are utilized **149**

149. a. Only raffinose is not utilized for growth **150**

b. No growth with sucrose and raffinose; aerial mycelium grayish-green or green **151**

150. a. Color of aerial mycelium is gray

St. flaveolus (Waksman) Waksman and Henrici. ISP 5061

b. Aerial mycelium grayish, later becoming reddish grayish brown or grayish yellowish pink on certain media

St. heimi (Duché) Pridham, Hesseltine, and Benedict. ISP 5328

151. a. Spore surface: Spiny to hairy

St. viridosporus Parke, Davis, and Co. ISP 5243

b. Spore surface hairy

Act. acrimycini Preobrazhenskaya, Blinov, and Ryabova. ISP 5135

152. a. Color of substrate mycelium: Y-b + yellow or orange ↔ red or violet; aerial mycelium gray; melanoid pigments are not formed in diagnostic media

Act. viridiviolaceus Ryabova and Preobrazhenskaya. ISP 5280

b. Color of substrate mycelium different **153**

153. a. Color of substrate mycelium: Y-b + red + green **154**

b. Color of substrate mycelium: Y-b + green **155**

154. a. Melanoid pigments are formed in peptone-yeast-iron agar and in tyrosine agar **Act. glaucescens** Preobrazhenskaya. ISP 5155

b. Melanoid pigments not formed

St. bambergiensis Lindner, Wallhäusser, and Huber. ISP 5590

155. a. D-Mannitol and D-fructose are utilized for growth; melanoid pig-

ments are formed in peptone-yeast-iron agar **156**

b. No growth with D-mannitol and D-fructose; melanoid pigments are not produced in peptone-yeast-iron agar

Act. finlayi Szabó, Marton, Buti, and Pártai. ISP 5218

156. a. Mature spore chains generally 10 to 50 spores per chain; aerial mycelium gray **Act. malachitofuscus** Preobrazhenskaya, Maximova, and Blinov. ISP 5332

b. Mature spore chains short, generally 3 to 10 spores per chain; aerial mycelium grayish-green or green

Act. griseomycini Preobrazhenskaya, Blinov, and Ryabova. ISP 5159; **Act. griseostramineus** Preobrazhenskaya, Kudrina, Ryabova, and Blinov. ISP 5161

157. a. Color of substrate mycelium: Y-b[2] **158**

b. Color of substrate mycelium different **212**

158. a. Melanoid pigments are produced in peptone-yeast-iron agar .. **159**

b. Melanoid pigments are not produced in peptone-yeast-iron agar **178**

159. a. Color of mature aerial mycelium blue or bluish green **160**

b. Color of aerial mycelium different **162**

160. a. Melanoid pigments not formed in tyrosine agar

St. amakusaensis Nagatsu, Ansai, Ohkuma, and Suzuki. ISP 5219

b. Melanoid pigments formed in tyrosine agar **161**

161. a. D-Mannitol is utilized for growth

St. azureus Donovick, Pagano, and Vandeputte. ISP 5106

b. No growth with D-mannitol

St. caelestis De Boer, Dietz, Wilkins, Lewis, and Savage. ISP 5084

162. a. Aerial mycelium red or reddish on certain media **163**

b. Aerial mycelium not red or reddish (but generally gray or grayish) **172**

163. a. i-Inositol is utilized for growth **164**

b. No growth with i-inositol **170**

164. a. Rhamnose is utilized for growth **165**

b. No growth with rhamnose **167**

165. a. No growth with raffinose

St. phaeofaciens Maeda, Okami, Taya, and Umezawa. ISP 5367

[2] Except for strain ISP 5261 of St. tubercidicus, the yellow-brown substrate mycelium of which may change to pale pink with addition of 0.05 *N* NaOH: Y-b + red.

b. Raffinose is utilized for growth **166**

166. a. Melanoid pigments are not formed on tyrosine agar
St. collinus Lindenbein. ISP 5129

b. Melanoid pigments produced (Aurantiogriseus group)
Act. aurantiogriseus Preobrazhenskaya. ISP 5138; **St. luteogriseus** Schmitz, Deak, Crook, and Hooper. ISP 5483

167. a. Sucrose is utilized for growth
St. anandii Batra and Bajaj. ISP 5535

b. No growth with sucrose **168**

168. a. Raffinose is utilized for growth **169**

b. No growth with raffinose (Luridus group)
Act. lavendocolor Kuchaeva, Krasil'nikov, Taptikova, and Gesheva. ISP 5216; **Act. lavendofoliae** Kuchaeva, Krasil'nikov, Taptikova, and Gesheva. ISP 5217; **Act. luridus** Krasil'nikov, Korenyako, Meksina, Valedinskaia, and Vesselov. ISP 5081

169. a. Soluble red pigment may be seen in yeast-malt agar and salts-starch agar. This pigment is not pH sensitive
St. chromogenus Isono, Suzuki, Sawazaki, Nakamura, Kawasaki, Yamashita, Anzai, Serizawa, and Sekiyama. ISP 5384

b. No pigment or only a trace of yellowish brown in the diagnostic media **St. atrofaciens** Ehrlich, Bartz, and Knudsen. ISP 5475

170. a. D-Xylose is utilized for growth **171**

b. No growth with D-xylose (and L-arabinose and raffinose) (Lavendulae group) **St. avidinii** Stapley, Mata, Miller, Demny, and Woodruff. ISP 5526; **St. goshikiensis** Niida. ISP 5190; **St. griseolavendus** Sumiki. ISP 5385; **St. lavendulae** (Waksman and Curtis) Waksman and Henrici. ISP 5069; **Act. toxytricini** Preobrazhenskaya and Sveshnikova. ISP 5178; **St. virginiae** Grundy, Whitman, Rdzok, Rdzok, Hanes, and Sylvester. ISP 5094

171. a. No growth with sucrose
St. cirratus Koshiyama, Okanishi, Ohmori, Miyaki, Tsukiura, Matzuzaki, and Kawaguchi. ISP 5479

b. Sucrose is utilized for growth
St. katrae Gupta and Chopra. ISP 5550

172. a. D-Glucose, L-arabinose, D-xylose, i-inositol, D-mannitol, D-fructose, rhamnose, sucrose and raffinose are all utilized for growth

(Diastatochromogenes group)
St. bottropensis Waksman. ISP 5262; **St. diastatochromogenes** (Krainsky) Waksman and Henrici. ISP 5449; **St. eurythermus*** Corbaz, Ettlinger, Gäumann, Keller-Schierlein, Neipp, Prelog, Reusser, and Zähner. ISP 5014; **St. griseosporeus** Niida and Ogasawa. ISP 5562; **St. neyagawaensis** Yamamoto, Nakazawa, Horii, and Miyake. ISP 5588; **St. versipellis** Oliver, Prokop, Sinclair, Warren, and Winfield. ISP 5491

b. No growth with certain diagnostic C-sources **173**

173. a. D-Mannitol is utilized for growth **175**

b. No growth with D-mannitol **174**

174. a. No growth with rhamnose and i-inositol
St. nashvillensis McVeigh and Reyes. ISP 5314

b. Rhamnose and i-inositol are utilized for growth (Galilaeus group)
St. galilaeus Ettlinger, Corbaz, and Hütter. ISP 5481; **St. rishiriensis** Kawaguchi, Tsukiura, Okanishi, Miyaki, Ohmori, Fuyisawa, and Koshiyama. ISP 5489

175. a. Melanoid pigments are not produced in tyrosine agar
St. galbus Frommer. ISP 5089

b. Melanoid pigments are produced in tyrosine agar **176**

176. a. No growth with rhamnose
St. galbus Okami and Umezawa. ISP 5480

b. Rhamnose is utilized for growth **177**

177. a. Sucrose is utilized for growth
St. lavenduligriseus* Routien. ISP 5487

b. No growth with sucrose **St. umbrosus** Schmidt-Kastner. ISP 5242

178. a. Color of mature aerial mycelium is red or reddish on certain media **179**

b. Aerial mycelium not red or reddish **189**

179. a. No growth with L-arabinose **180**

b. L-Arabinose is utilized for growth **182**

180. a. No growth with raffinose and D-mannitol
St. tenebrarius Higgens and Kastner. ISP 5477

b. Raffinose and D-mannitol are utilized **181**

181. a. No growth with i-inositol and sucrose
St. roseo-luteus Bessell. ISP 5240

b. i-Inositol and sucrose are utilized (Substrate mycelium yellow to yellowish brown on the dignostic media, but it is pH sensitive (!) changing from yellow to pink (Y-b + red) with addition of 0.05 *N* NaOH) **St. tubercidicus*** Nakamura. ISP 5261

182. a. Raffinose is utilized for growth **183**

b. No growth with raffinose **184**

183. a. D-Glucose, L-arabinose, D-xylose, i-inositol, D-mannitol, D-fructose, rhamnose, sucrose and raffinose are all utilized for growth (Graminofaciens group)

St. graminofaciens Charney, Fisher, Curran, Machlowitz, and Tytell. ISP 5559; **St. misionensis*** Cercós, Eilberg, Goyena, Souto, Vautier, and Widuczynski. ISP 5306; **St. ochraceiscleroticus** (Kuznetsov) Pridham. ISP 5594; **St. vinaceus-drappus** Anonymous. ISP 5470

b. No growth with i-inositol and sucrose

Act. fumanus Sveshnikova. ISP 5154

184. a. No growth with D-mannitol **185**

b. D-Mannitol is utilized for growth **187**

185. a. i-Inositol is utilized for growth

St. chryseus* (Krasil'nikov, Korenyako, and Nikitina) Pridham. ISP 5420; **St. helvaticus** (Krasil'nikov, Korenyako, and Nikitina) Pridham. ISP 5431

b. No growth with i-inositol **186**

186. a. No growth with D-xylose

Act. roseolilacinus Preobrazhenskaya and Sveshnikova. ISP 5173

b. D-Xylose is utilized for growth (Fradiae group)

Act. cremeus Kudrina. ISP 5147; **St. fradiae*** (Waksman and Curtis) Waksman and Henrici. ISP 5063; **St. roseoflavus** Arai. ISP 5536

187. a. i-Inositol is utilized for growth (Plicatus group)

St. humidus Nakazawa, Shibata, Tanabe, and Yamamoto. ISP 5263; **St. plicatus** Anonymous. ISP 5319

b. No growth with i-inositol **188**

188. a. No growth with rhamnose (Thermoviolaceus group)

St. griseofuscus Sakamoto, Kondo, Yumoto, and Arishima. ISP 5191; **St. thermoviolaceus** subsp. **thermoviolaceus*** (Henssen) Henssen and Schnepf. ISP 5443

b. Rhamnose is utilized for growth (Griseoviridis group) **Act. alborubidus*** Kudrina. ISP 5465; **Act. daghestanicus** Sveshnikova. ISP 5149; **St. griseoviridis** Anderson, Ehrlich, Sun, and Burkholder. ISP 5229; **St. rosa** Reusser. ISP 5533

189. a. Mature aerial mycelium green or greenish (Green color series in the Tresner-Backus system) on certain media **190**

b. Aerial mycelium gray, yellow (Yellow color series in the Tresner-Backus system) or white **192**

190. a. No growth with D-mannitol

St. psammoticus Virgilio and Hengeller. ISP 5341

b. D-Mannitol is utilized for growth **191**

191. a. No growth with sucrose and D-xylose

St. catenulae Davisson and Finlay. ISP 5258

b. Sucrose and D-xylose are utilized for growth

St. chrestomyceticus* Canevazzi and Scotti. ISP 5545; **Act. olivaceoviridis** Preobrazhenskaya and Ryabova. ISP 5334

192. a. D-Glucose, L-arabinose, D-xylose, i-inositol, D-mannitol, D-fructose, rhamnose, sucrose, and raffinose are all utilized for growth ... **193**

b. No growth with certain diagnostic carbon sources **194**

193. a. Mature aerial mycelium gray (Parvullus group)

Chainia nigra Thirumalachar. ISP 5302; **St. canarius** Vavra and Dietz. ISP 5528; **St. chibaensis** Suzuki, Nakamura, Okuma, and Tomiyama. ISP 5220; **St. corchorusii** Ahmad and Bhuiyan. ISP 5340; **St. libani*** Baldacci and Grein. ISP 5555; **St. lydicus*** De Boer, Dietz, Silver, and Savage. ISP 5461; **St. nigellus** Prokop. ISP 5490; **St. olivaceiscleroticus** Pridham. ISP 5595; **St. parvullus** Waksman and Gregory. ISP 5048; **St. pristinaespiralis** Mancy, Ninet, and Preud'homme. ISP 5338; **St. thermoflavus*** (Kudrina and Maximova) Pridham. ISP 5574; **St. thermovulgaris** Henssen. ISP 5444

b. Aerial mycelium white or whittish (Sclerotialus group)

St. purpurogeniscleroticus Pridham. ISP 5271; **St. sclerotialus** Pridham. ISP 5269

194. a. Mature aerial mycelium gray **195**

b. Mature aerial mycelium white or yellow (Yellow color series in the Tresner-Backus system) **205**

195. a. No growth with i-inositol **196**

b. i-Inositol is utilized for growth **199**

196. a. Rhamnose is utilized for growth

St. endus Anderson and Gottlieb. ISP 5187

b. No growth with rhamnose **197**

197. a. Raffinose is utilized for growth

St. griseoplanus Backus, Tresner, and Campbell. ISP 5009

b. No growth with raffinose **198**

198. a. No growth with sucrose

St. halstedii (Waksman and Curtis) Waksman and Henrici. ISP 5068

b. Sucrose is utilized for growth (Aureofaciens group)

St. aureofaciens Duggar. ISP 5127; **St. viridifaciens** Gourevitch and Lein. ISP 5239

199. a. No growth with rhamnose **200**

b. Rhamnose is utilized for growth **202**

200. a. No growth with L-arabinose **201**

b. L-Arabinose is utilized for growth (Albofaciens group)

St. albofaciens Thirumalachar and Bhatt. ISP 5268; **St. capuensis** Baldacci, Farina, Locci, and Ragni. ISP 5402

201. a. No growth with raffinose

St. thermonitrificans Desai and Dhala. ISP 5579

b. Raffinose is utilized for growth (Nigrescens group)

Act. nigrescens Sveshnikova. ISP 5276; **St. sioyaensis** Nishimura, Okamoto, Mayama, Ohtsuka, Nakajima, Tawara, Shimohira, and Shimaoka. ISP 5032

202. a. No growth with raffinose **203**

b. Raffinose is utilized for growth **204**

203. a. No growth with sucrose (Olivaceus group)

St. nodosus Trejo. ISP 5109; **St. olivaceus** (Waksman) Waksman and Henrici. ISP 5072; **St. pulcher** Routien. ISP 5566; **St. rochei** Berger, Jampolsky, and Goldberg. ISP 5231

b. Sucrose is utilized for growth (Albogriseolus group)

St. albogriseolus Benedict, Shotwell, Pridham, Lindenfelser, and Haynes. ISP 5003; **St. tendae** Ettlinger, Corbaz, and Hütter. ISP 5101; **Act. mutabilis** Preobrazhenskaya and Ryabova. ISP 5169

204. a. No growth with D-mannitol

St. naraensis* Okuda, Ashino, Egawa, and Suzuki. ISP 5508

b. D-Mannitol is utilized for growth

St. melanosporofaciens Arcamone, Bertazzoli, Ghione, and Scotti. ISP 5318

205. a. No growth with D-xylose

St. paraguayensis (de Almeida) Waksman. ISP 5567

b. D-Xylose is utilized for growth **206**

206. a. Rhamnose is utilized for growth **208**

b. No growth with rhamnose **207**

207. a. No growth with D-mannitol

Act. albohelvatus* Krasil'nikov, Korenyako, and Nikitina. ISP 5410

b. D-Mannitol is utilized for growth

St. albus (Rossi-Doria) Waksman and Henrici. ISP 5313; **St. almquisti** (Duché) Pridham, Hesseltine, and Benedict. ISP 5447; **St. aminophilus** Wooldridge. ISP 5186; **St. cacaoi** (Waksman) Waksman and Henrici. ISP 5057; **St. citreus** Waksman and Henrici. ISP 5364; **St. diastaticus** (Krainsky) Waksman and Henrici. ISP 5496; **St. rangoon** (Erickson) Pridham, Hesseltine, and Benedict. ISP 5452

208. a. No growth with D-mannitol

Act. aurigineus* Krasil'nikov, Korenyako, and Nikitina. ISP 5417; **Act. flavidovirens*** Kudrina. ISP 5150

b. D-Mannitol is utilized for growth **209**

209. a. No growth with i-inositol **210**

b. i-Inositol is utilized for growth **211**

210. a. Sucrose is utilized for growth

St. spheroides Wallick, Harris, Reagen, Ruger, and Woodruff. ISP 5292

b. No growth with sucrose

St. anulatus (Beijerinck) Waksman. ISP 5361; **St. niveus*** Smith, Dietz, Sokolski, and Savage. ISP 5088

211. a. No growth with sucrose

Act. longisporus-flavus* Krasil'nikov. ISP 5165; **St. minutiscleroticus** (Thirumalachar) Pridham. ISP 5301; **St. sulphureus*** (Gasperini) Waksman. ISP 5104; **St. pseudogriseolus** Okami and Umezawa. ISP 5026

b. Sucrose is utilized for growth

St. flocculus* (Duché) Waksman and Henrici. ISP 5327

212. a. Color of substrate mycelium: Y-b + green + blue (Melanoid pigments not formed in diagnostic media; presumedly all diagnostic carbon sources are utilized) **St. vastus** Szabó and Marton. ISP 5309

b. Color of substrate mycelium different **213**

213. a. Color of substrate mycelium: Y-b + red **214**

b. Color of substrate mycelium different **232**

214. a. Melanoid pigments not formed in peptone-yeast-iron agar **215**

b. Melanoid pigments produced **224**

215. a. No growth with D-mannitol **216**

b. D-Mannitol is utilized for growth **218**

216. a. No growth with D-fructose

St. fragilis Anderson, Ehrlich, Sun, and Burkholder. ISP 5044

b. D-Fructose is utilized for growth **217**

217. a. No growth with raffinose

St. spiroverticillatus Shinobu. ISP 5036

b. Raffinose is utilized for growth

St. bobili (Waksman and Curtis) Waksman and Henrici. ISP 5056

218. a. No growth with L-arabinose **St. murinus** Frommer. ISP 5091

b. L-Arabinose is utilized for growth **219**

219. a. Short spore chains containing 3 to 10 (or more than 10) spores per chain **220**

b. Long spore chains containing 10 to 50 or more spores per chain **221**

220. a. No growth with i-inositol

St. luteofluorescens Shinobu. ISP 5398

b. i-Inositol is utilized for growth

Act. aurantiacus (Rossi-Doria) Krasil'nikov. ISP 5412; **St. poonensis** (Thirumalachar) Pridham. ISP 5596; **St. rimosus** (Sobin, Finlay, and Kane) Waksman. ISP 5260

221. a. No growth with rhamnose

Act. aureoverticillatus Krasil'nikov and Yün Chi-sheng. ISP 5080; **St. platensis*** Pittenger and Gottlieb. ISP 5041

b. Rhamnose is utilized for growth **222**

222. a. Orange or red soluble pigment in certain diagnostic media .. **223**

b. No soluble pigment **St. roseiscleroticus** Pridham. ISP 5303

223. a. No growth with i-inositol

St. nogalater* Bhuyan and Dietz. ISP 5546

b. i-Inositol is utilized for growth

St. griseoaurantiacus (Krasil'nikov and Yuan) Pridham. ISP 5430; **St. minoensis** Nishimura. ISP 5031

224. a. No growth with D-mannitol **225**

b. D-Mannitol is utilized for growth **227**

225. a. Raffinose is utilized for growth

Act. kurssanovii Preobrazhenskaya, Kudrina, Ryabova, and Blinov. ISP 5162

b. No growth with raffinose **226**

226. a. D-Xylose, rhamnose, i-inositol and L-arabinose are utilized for growth

St. griseoruber Yamaguchi and Saburi. ISP 5281

b. No growth with D-xylose, rhamnose, i-inositol and L-arabinose

St. colombiensis* Pridham, Hesseltine, and Benedict. ISP 5558

227. a. Pseudo-verticillate branching is common

St. nobilis Baldacci, Locci, and Farina. ISP 5441

b. Pseudo-verticillate branching very rare **228**

228. a. D-Glucose, L-arabinose, D-xylose, i-inositol, D-mannitol, D-fructose, rhamnose, sucrose and raffinose are all utilized for growth ... **229**

b. No growth with certain carbon sources **231**

229. a. Short spore chains containing 3 to 10 or more spores per chain

Act. violochromogenes Artamonova and Krasil'nikov. ISP 5207

b. Spore chains containing 10 to 50 or more spores per chain .. **230**

230. a. No soluble pigment; spore chains containing 10 to 50 spores per chain; aerial mycelium gray

St. resistomycificus Lindenbein. ISP 5133

b. Soluble pigment red or lavender; spore chains containing more than 50 spores per chain; aerial mycelium red

Act. cinnabarinus Ryabova and Preobrazhenskaya. ISP 5467; **St. coralus** Dietz. ISP 5256

231. a. Rhamnose and i-inositol are utilized for growth

St. naganishii Yamaguchi and Saburi. ISP 5282

b. No growth with rhamnose and i-inositol

Act. varsoviensis Kuryłowicz and Woźnicka. ISP 5346; **St. vinaceus** Jones. ISP 5515

232. a. Color of substrate mycelium: Y-b + green[3] **233**

b. Color of substrate mycelium different **238**

233. a. Melanoid pigments are formed in peptone-yeast-iron agar

St. regensis Gupta, Sobti, and Chopra. ISP 5551

[3] There are two "species" of Streptomyces, not included in this determining key, in the case of which the color of substrate mycelium varies between blue and green (this pigment is not pH indicator or is modified only very slightly):
1. **St. ipomoeae** (Person and Martin) Waksman and Henrici. Strain ISP 5383 produces incomplete spirals of 1 or 2 turns, smooth spores, blue aerial mycelium; it utilizes all diagnostic carbon sources but does not produce melanoid pigments.
2. **St. mirabilis** Ruschmann. Strain ISP 5553 produce spiral sporophores, smooth spores, gray aerial mycelium, melanoid pigments in peptone-yeast-iron agar but not in tyrosine agar; utilizes D-glucose, L-arabinose, i-inositol, D-mannitol, D-fructose and rhamnose.

b. Melanoid pigments are not formed in peptone-yeast-iron agar **234**

234. a. D-Glucose, L-arabinose, D-xylose, i-inositol, D-mannitol, D-fructose, rhamnose, sucrose and raffinose are all utilized for growth
St. violaceoniger (Waksman and Curtis) Waksman and Henrici. ISP 5563

b. No growth with certain diagnostic C-sources **235**

235. a. No growth with L-arabinose and D-mannitol
St. xantholiticus (Konev and Tsyganov) Pridham. ISP 5244

b. L-Arabinose and D-mannitol are utilized **236**

236. a. Sucrose and raffinose are utilized for growth (No growth on i-inositol and rhamnose) **St. recifensis** de Morais, de Lima, and Maia. ISP 5115

b. No growth with sucrose and raffinose **237**

237. a. Rhamnose is utilized for growth, spore chains containing 10 to 50 or more spores per chain
St. argenteolus Fried, Perlman, Langlykke, and Titus. ISP 5226

b. No growth with rhamnose; spore chains containing 3 to 10 spores per chain **St. rutgersensis** (Waksman and Curtis) Waksman and Henrici. ISP 5077

238. a. Color of substrate mycelium: Y-b + blue (No melanoid pigments in peptone-yeast-iron agar)
St. ambofaciens Pinnert-Sindico. ISP 5053

b. Color of substrate mycelium: Y-b + red ↔ blue[4] **239**

239. a. Melanoid pigments are produced in peptone-yeast-iron agar .. **240**

b. Melanoid pigments not produced in peptone-yeast-iron agar; red to blue pigment in the medium is pH sensitive, showing the same changes noted for the reverse mycelium pigment; aerial mycelium gray to grayish sometimes modified by red or blue owing to the interference with the red or blue colored substrate mycelium; D-glucose, L-arabinose, D-mannitol, D-fructose, D-xylose, rhamnose, and i-inositol are utilized for growth (Violaceoruber group)
St. caesius (Krasil'nikov, Sorokina, Alferova, and Bezzubenkova) Pridham. ISP 5419; **St. coelescens** (Krasil'nikov, Sorokina, Alferova, and Bezzubenkova) Pridham. ISP 5421; **Act. cyanocolor** Krasil'nikov, Sorokina, Alferova, and Bezzubenkova. ISP 5425; **Act. cyanogenus** Krasil'nikov, Sorokina, Alferova,

[4] The yellow-brown substrate mycelium color of strain ISP 5194 of St. racemochromogenus may be modified in some areas by a pigment varying between blue and green. This pigment is a pH indicator changing from grayish green, blue or violet to reddish gray.

and Bezzubenkova. ISP 5426; **St. lazureus** (Krasil'nikov, Sorokina, Alferova, and Bezzubenkova) Pridham. ISP 5433; **St. lividans** (Krasil'nikov, Sorokina, Alferova, and Bezzubenkova) Pridham. ISP 5434; **Act. violaceolatus** Krasil'nikov, Sorokina, Alferova, and Bezzubenkova. ISP 5438; **St. violaceoruber** (Waksman and Curtis) Kutzner and Waksman. ISP 5049

240. a. D-Glucose, L-arabinose, D-xylose, i-inositol, D-mannitol, D-fructose, rhamnose, sucrose and raffinose are all utilized for growth ... **241**

b. No growth with certain diagnostic carbon sources **242**

241. a. Short spore chains with 3 to 10 or, sometimes more than 10, spores per chain; yellow or yellow-brown pigment in the media not pH sensitive **Act. violaceochromogenes** (Krasil'nikov) Ryabova and Preobrazhenskaya. ISP 5181

b. Spore chains 10 to 50 spores per chain; no pigment in the medium or when pigment is present it is blue ↔ red (pH sensitive) (Massasporeus group) **St. massasporeus** Shinobu and Kawato. ISP 5035; **St. tauricus** (Ivanitskaya, Upiter, Sveshnikova, and Gauze) Pridham. ISP 5560

242. a. Rhamnose is utilized for growth **243**

b. No growth with rhamnose **244**

243. a. Short spore chains with 3 to 10 or more spores per chain; no growth with i-inositol, D-mannitol and raffinose **St. cyaneogriseus** (Yen) Pridham. ISP 5534

b. Mature spore chains generally 10 to 50 spores per chain; no growth on sucrose, D-mannitol and raffinose. Utilization of i-inositol is doubtful **Act. lateritius** Sveshnikova. ISP 5163

244. a. D-Mannitol is utilized for growth **St. capoamus** Gonçalves de Lima, Albert, and Gonçalves de Lima. ISP 5494

b. No growth with D-mannitol **245**

245. a. Sucrose is utilized for growth; mature aerial mycelium red; no soluble pigment (The blue pigment of substrate mycelium is not always present. When present, it can be intensified from grayish green to grayish blue or violet by 0.05 *N* NaOH or to reddish gray by 0.05 *N* HCl) **St. racemochromogenus**[4] Sugai. ISP 5194

b. No growth with sucrose; mature aerial mycelium gray; blue ↔ red soluble pigment **Act. litmocidini** Ryabova and Preobrazhenskaya. ISP 5164

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A STUDY OF THE NUTRIENT CONTENT OF CANOPY THROUGHFALL IN AN OAK FOREST (QUERCETUM PETRAEAE-CERRIS) MEASURED FOR ONE YEAR*

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Changes in the quantity of eleven different elements present in atmospheric precipitation carried by canopy throughfall onto the soil have been studied in a climate zonal oak forest in 1974. The study was based on monthly measurements of the quantity of nutrient materials present in the collected water samples under the community foliage of *Quercus petraea*, *Quercus cerris*, *Quercus petraea* and *Cornus mas*, *Qu. petraea* and *Acer campestre*. For each element, the degree of enrichment has been measured, taking atmospheric precipitation as a basis. By knowing the quantity of water, the degree of canopy density and concentration, the quantity of minerals present in the throughfall arriving on 1 hectare of forest soil could be established (per element, on a monthly or annual basis).

Introduction

One of the main purposes of extensively pursued research programmes in ecosystems in the past decade has been a cognition of the mineral cycles. It is only recently that the study of the nutrients — the input branch of the nutrient cycle — deposited from the atmosphere by the way of precipitation in the ecosystems is becoming of increasing interest. Madgwick and Ovington (1959), Nye (1961), Carlisle et al. (1966), Likens et al. (1967), Rapp (1969), Denaeyer-De Smet (1969), Ulrich et al. (1971), Reiners (1972), Gubareva (1973) and others have measured the quantity of nutrients in precipitation received by the various ecosystems and investigated the role of vegetation played in enriching the mineral content of rainwater. Quantities of the most important nutrients carried by rainfall into the climate zonal forest ecosystem of the temperate zone has been studied by Ovington (1968). Allen et al. (1968) point out that the quantity of minerals present in rainwater can be of special significance in the nutrient cycle of ecosystems, especially in nutrient-poor areas. Similar investigations have also been conducted in various parts of Hungary (Kozák and Mészáros, 1971a, b) chiefly with the purpose to assess atmospheric pollution and from agrochemical points of view.

* "Síkfőkút Project" No. 17.

Precipitation water itself carries a certain quantity of nutrients obtained from airborne dust, gases, etc. whose content of bioelements undergoes significant changes once they gain excess to the ecosystem. In forests rainwater falling on foliar surfaces, branches and stems washes off the dust and concurrently leaches a portion of the nutrient elements from them (TAMM, 1958; STENLID, 1958; TUKEY, 1970; etc.). As a result, rainwater is already enriched in nutrient elements to a certain extent when it arrives on the soil surface.

A significant portion of the nutrients is recycled into the soil of the forest ecosystem by means of leaf litter, its decomposition and precipitation, respectively. DUVIGNEAUD et al. (1971) demonstrated that in temperate zone forests three-fourths of the total amount of circulating minerals is returned to the soil with leaf litter, throughfall, and stemflow. According to CARLISLE et al. (1967), DUVIGNEAUD et al. (1971) and NEBE (1973), 50% of the total amount of potassium arrives into the soil with canopy throughfall and stemflow annually. A large portion of magnesium finds its way back to the soil in the same way. In the case of calcium and sodium, the return through litter and its decomposition is of greater significance.

Since the understanding of the nutrient cycles of forest ecosystems requires complex and multilevelled investigations, their study is compartamentalized and the results subsequently interrelated.

Description of study site

Our study is an integral part of the studies in the MAB Programme (JAKUCS, 1973), concerning the complex investigations of forest ecosystems in Hungary. Investigations were carried out in a 65 to 70 years old, climate zonal oak forest of homogeneous stand, located in the hilly land between the Great Hungarian Plain and the Northern mountain range (*Quercetum petraeae-cerris*) (Síkfőkút Project). *Quercus petraea* dominates in the foliage level (84%), followed by *Qu. cerris* (16%). Canopy density is 80%, the average tree height 17.3 m, average trunk diameter 20 cm, average number of trees per hectare 816. The shrub level is also well-developed: e.g. *Cornus mas*, *Acer campestre*, *Acer tataricum*, *Ligustrum vulgare* occur in masses. Structural data and detailed characterization of the environment and climate are supplied by JAKUCS and (1973) JAKUCS et. al. (1975).

Methods

Atmospheric precipitation and throughfall water samples were collected biweekly, at times weekly, (on 23 sampling occasions), between February 27 and December 4, 1974, in the experimental area covering 1/4 hectare ("B" square). An account on the amount of precipitation (canopy throughfall and stemflow) arriving on the forest floor as well as on interception and its

annual changes had been given in an earlier study (SZABÓ 1975). In the investigation period the amount of precipitation was 595.3 mm according to our measurements.

Input precipitation was captured in a trough made of polyester with a collecting surface of 2000 cm^2 placed on the top of a tower 25 m high, and water was trapped in a black-coloured plastic container. Troughfall was captured by 14 troughs, of identical dimensions as the former one, applied in four combinations; 5 collectors under *Qu. petraea*, 3 collectors under *Qu. cerris*, 3 collectors under *Qu. petraea* + *Cornus mas* and 3 collectors under *Qu. petraea* + *Acer campestre*. A nylon filter of 1 mm mesh size was placed in front of the drainage orifice of the collectors, in order to block the way of macroscopic litter, twigs and invertebrates. After each sampling, thymol was put into the collectors to prevent the proliferation of microorganisms, since they incorporate nitrogen and phosphorus present in water. The iodine treatment suggested by HERON (1962) is generally employed as a preventive method but this treatment is rather complicated.

In every instance 500 ml well homogenized water sample was taken and stored in a dark refrigerator until chemical processing. Elements present in the precipitation water samples collected at each sampling point were determined monthly. Prior to analysis, the month-old water samples were mixed in a ratio based on the quantity of each sample filtered and analysed with respect to the following elements: K, Ca, Na, Mg, Fe, Mn, Zn, SO_4-S, PO_4-P, NO_3-N, KJELDAHL-N, and Cl. Cations have been determined by a UNICAM SP 1900 type atomic absorption spectrophotometer, at the Institute for Inorganic Chemistry. Kossuth University, Debrecen.

Organic-N was measured by KJELDAHL digest. The NH_3 content of the sample was distilled through a modified PARNASS—WAGNER apparatus into saturated H_3BO_4 solution and mixed (Groak) indicator and the NH_3 determined through titration with HCl.

Determination of the total phosphate content: the forms of phosphorus present in the water sample were first converted into orthophosphate by KJELDAHL digest, then the mixed reagent (H_2SO_4 + ammonium molybdate + $SbCl_3$ amydosulphonic acid was added as a reagent followed by the addition of ascorbic acid as the reducing agent. Colorimetry was performed with a SPEKOL Spectrophotometer on 665 nm wavelength.

Nitrate was also determined by colorimetry. The NO_3 ions turn yellow in the presence of Na-salicilate in acidic medium. Colour intensity was measured on 420 nm wavelength.

The quantity of sulphate was measured again by the colorimetric method. SO_4 ions were precipitated in a known quantity of $BaCl_2$ solution, then the remnant of Ba was photometrically measured with the aid of K_2CrO_4 solution on 400 nm wavelength.

Chloride was determined by OP-Cl-7112-D type chloride selective electrode and pH measurer.

Results and discussion

Concentration changes of the analysed elements is shown in Figures 1/a, b and c. The quantity of the nutrient elements deposited by canopy throughfall has been calculated for 1 hectare forest floor, on the basis of the cover map and the respective density values. They were as follows: 27% for *Qu. petraea*, 13% for *Qu. cerris*, 20% for *Qu. petraea* + *Acer campestre*, 20% for *Qu. petraea* + *Cornus mas*. Cover values indicate that in the experimental forest the open area is 20% of the total surface where the total mineral content of the unintercepted precipitation reaches the soil. Thus, when calculating the grand total of mineral quantity received by 1 hectare of florest floor, 20% was added to the amount present in the throughfall (80% canopy cover).* The end result per element (the four experimental combinations on an annual

* Mineral content of the stemflow will be discussed in a later paper.

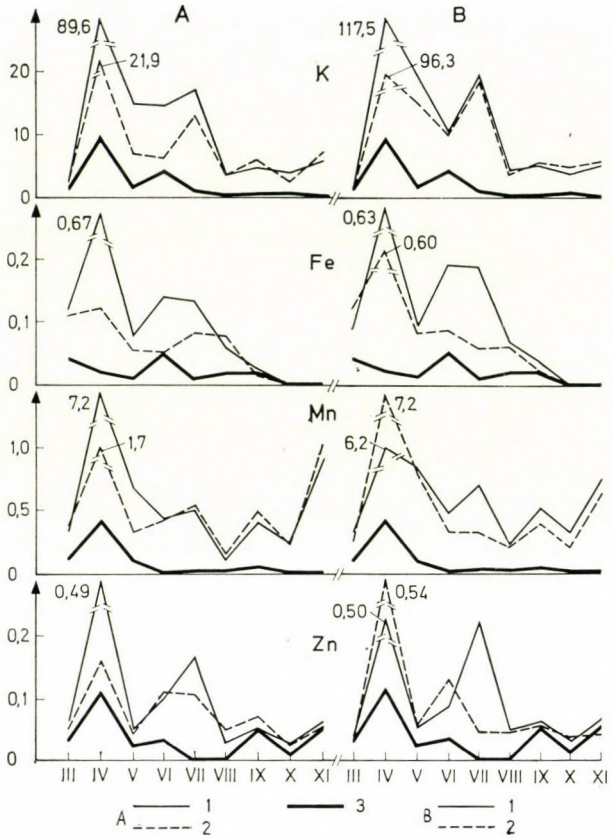

Fig. 1a. Changes in K, Fe, Mn, and Zn concentrations (in mg/liter) in canopy throughfall and in atmospheric precipitation; A1 = Quercus petraea; A2 = Quercus cerris; B1 = Qu. petraea and Acer campestre; B2 = Qu. petraea and Cornus mas; 3 = atmospheric precipitation

basis) is illustrated in Fig. 2. The annual grand total of nutrient elements in atmospheric precipitation, throughfall, and in the 20% of unintercepted precipitation is summarized in Fig. 3.

A so-called enriching factor has been calculated for each element, whereby the enrichment level of each element in throughfall is compared with the quantity present in incident rainfall.

Table 1 summarizes the changes in the nutrient content of atmospheric precipitation and of canopy throughfall (in all four investigated combinations) expressed in kg/ha, as well as the differences (between throughfall and atmospheric precipitation) and the enrichment factors per month and per year. An enrichment factor less than 1 indicates that the concentration level of the element in canopy throughfall was smaller than that of the level of concentration atmospheric precipitation.

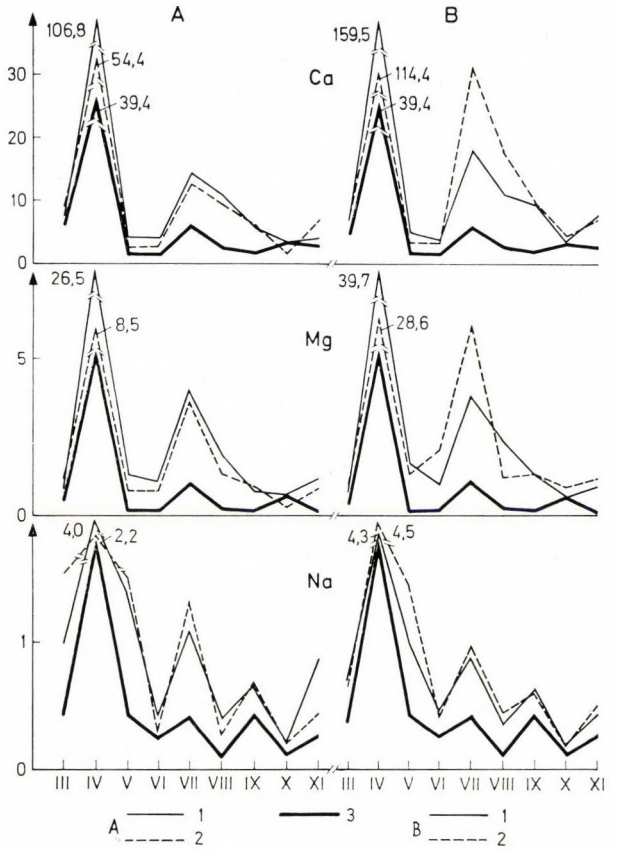

Fig. 1b. Changes in Ca, Mg, Na concentrations (in mg/liter) in canopy throughfall and in atmospheric precipitation. For numerical designation see Fig. 1a

Potassium

During the period of investigation, the amount of potassium in atmospheric precipitation was 7.43 kg/ha. This quantity is higher than measured by MADGWICK and OVINGTON (1959) (2.8 kg/ha/annum) and is closer to the data submitted by WILL (1959) (2.35—10.42 kg/ha/annum) who conducted measurements in New Zealand. The measured potassium content of canopy throughfall in the investigated oak forest — for the period of investigation — was 27.016 kg/ha, approaching the value measured by CARLISLE et al. (1966), namely 28.14 kg/ha/annum also in a *Quercus petraea* forest. The increase of potassium content in canopy throughfall is very significant, 19.587 kg/ha, representing the highest value among all macroelements (Fig. 2).

28.51 kg/ha potassium, carried by rainwater, has reached the soil of the

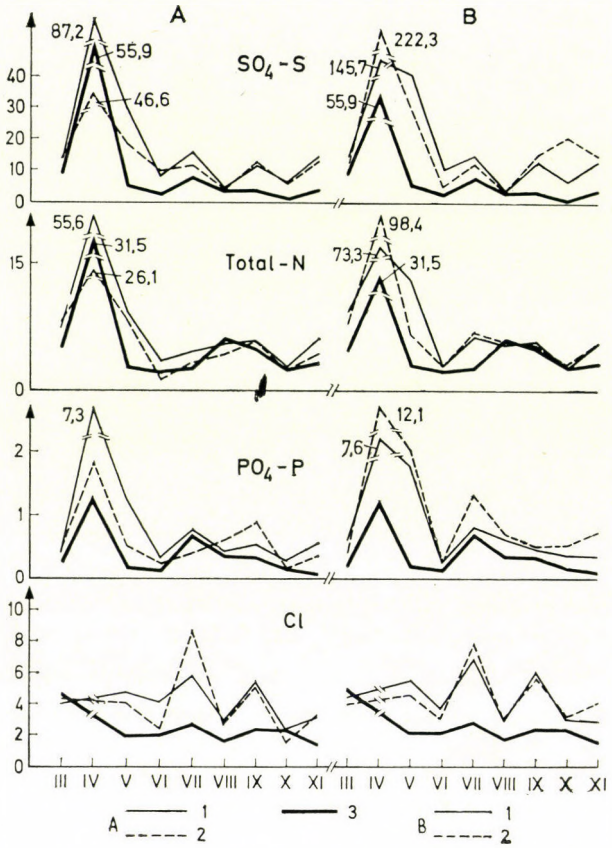

Fig. 1c. Changes in SO_4-S, total-N, PO_4-P, and Cl concentrations (in mg/liter) in canopy throughfall and in atmospheric precipitation. For numerical designation see Fig. 1a

ecosystem (canopy throughfall + 20% unintercepted precipitation) during the period of examination (Fig. 3).

Our measurements yielded maximum values with respect to potassium concentration in canopy throughfall, one maximum value for the summer and one again for the autumn, not including, however, the outstanding value measured in April when all other investigated elements indicated a significant level height, a fact which was related to the extraordinary low amount of precipitation (3.3 mm). This maximum will not be considered in the case of any of the other elements.

Increase in the potassium content of canopy throughfall is best illustrated by the enrichment factors (Table 1). The level of enrichment is highest in the months of July, August and November during which time the potassium content of canopy throughfall has increased by ten to thirtyfold. This phenomenon is probably strictly related to the fact that rainwater readily leaches

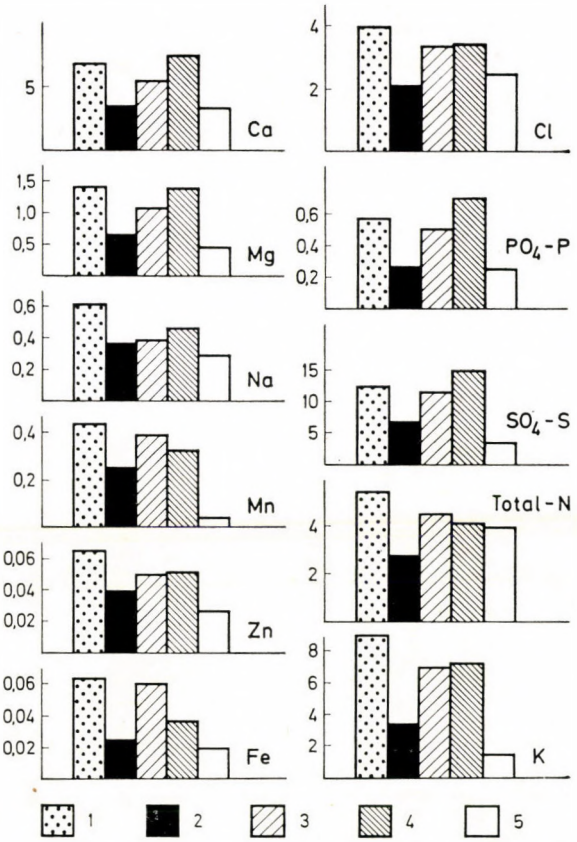

Fig. 2. Distribution of minerals arriving penetrating the soil; 1 = Quercus petraea; 2 = Quercus cerris; 3 = Qu. petraea and Acer campestre; 4 = Qu. petraea and Cornus mas; 5 = direct penetration into the soil

potassium from fully developed leaves and from those beginning to turn yellow. According to TUKEY (1970), the amount of leached potassium is only 5% in the case of young leaves, leached potassium can amount to 80% from senescent leaves, despite the fact that developing leaves possess a larger amount of the element.

The changes of potassium content in canopy throughfall of *Qu. petraea* and *Qu. cerris* concurs with the changes of potassium concentration in atmospheric precipitations (Fig. 1a). In the case of *Qu. petraea*, enrichment is significant until the beginning of August. The most likely explanation lies in the differences of leaf morphology and structure between the two tree species. Deviation is less in the case of tree-shrub combinations of the two species; beginning with June, there is practically no marked difference in the potassium content of canopy throughfall. Compared with the quantities of potassium leached only from tree foliage, water falling through the canopies of also

the two shrub species is more significantly enriched. The largest amount of potassium reaching the forest floor with canopy throughfall was in June (6.782 kg/ha); slightly less was measured in May (6.560 kg/ha, Fig. 2). The potassium content of canopy throughfall for May and June was nearly as high in a *Qu. petraea* forest, measured by CARLISLE et al. (1966). An increase could be observed again in October (5.255 kg/ha). This might be explained also by the high level of precipitation in October, 1974 (194 mm atmospheric precipitation).

Calcium

Although in atmospheric precipitation only Ca among the cations occurred in the greatest amount — 17.40 kg/ha in the investigation period — the Ca-content of canopy throughfall was only 23.28 kg/ha. The increase was therefore only 5.88 kg/ha (Table 1). And 26.76 kg/ha Ca has reached the soil (Table 1). The Ca-content of canopy throughfall on the forest floor exhibited a steady trend increase until the end of the summer and has reached maximum level in August (6.371 kg/ha); after an intermediate decrease in September, Ca-content had again increased by October (4.357 kg/ha, Fig. 2). This last increase can be related also with the higher amount of precipitation.

Input Ca (17.40 kg/ha) during the investigated period was considerably higher than that cited by CARLISLE et al. (1966) (7.3 kg/ha/annum), and as measured by MADGWICK and OVINGTON (1959) (11 kg/ha/annum). Ca-enrichment shows a significantly smaller rate in canopy throughfall than does potassium. Maximum enrichment (sixfold) was registered also in July and August, especially in the case of the combination *Qu. petraea* + *Cornus mas*. According to NEBE (1973), the increase of Ca concentration during the summer is probably owing to dust being washed off by rainwater from the leaves. By the end of the vegetation period, in November, Ca concentration of canopy throughfall shows a slight increase, owing probably to the loss of Ca from the dead leaves. There is no considerable difference between the Ca-content in the precipitation fallen through the canopies of *Qu. petraea* and *Qu. cerris*. The Ca-content of throughfall for both tree and shrub combinations and its level are always higher. The canopy throughfall of *Qu. petraea* + *Acer campestre* is always higher in Ca-content until June, than that falling through *Qu. petraea* + *Cornus mas*. This phenomenon can be adequately accounted for by the higher Ca-content in the leaves of the two shrub species than in those of the trees (PAPP L. ined.).

Magnesium

Magnesium occurs in considerable quantity both in atmospheric precipitation and in canopy throughfall. During the investigation period, atmospheric precipitation contained 2.31 kg/ha Mg, canopy throughfall 4.55 kg/ha, making

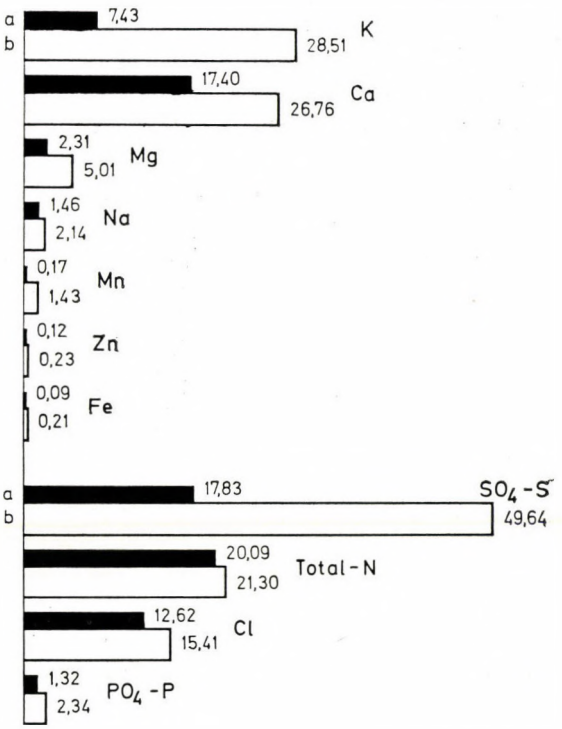

Fig. 3. Bioelement content of atmospheric precipitation (a) and rainfall reaching the soil (b) in kg/ha

a difference of 2.24 kg/ha (Table 1). During the time of study, 5.01 kg/ha Mg arrived with rainwater on the soil (Fig. 3). There is little information in literature on the investigation of Mg-content; CARLISLE et al. (1966) measured 4.63 kg/ha/annum in atmospheric precipitation. Mg concentration in canopy throughfall (Fig. 1) shows changes similar to those in Ca-content, but of lower values. Concentration maxima were reached in the same periods; the high values registered in the summer were probably the result of higher dust pollution, and maximum values measured in November probably owing to the extensive leaching of Mg from the leaves.

If the four combinations are compared, no great difference between the Mg-contents of canopy throughfall of the two tree species can be noticed. Mg enrichment in the throughfall of tree shrub combinations is more significant, especially in the case of *Qu. petraea* + *Cornus mas*. The greatest amount of Mg present in canopy throughfall has reached the soil in July and August, 0.876 and 0.883 kg/ha, respectively; this amount again increased after a setback in September, to 0.823 kg/ha in October. Maximum Mg enrichment was measured in the canopy throughfall of *Qu. petraea* + *Cornus mas* in July, the enrichment factor then was 13.

Sodium

During the study period, the sodium content in canopy throughfall was 1.84 kg/ha (Table 1). Maximum Na quantity in canopy throughfall occurred in May (0.596 kg/ha), and after a decrease in summer it again increased to 0.318 kg/ha in October. This later increase can be explained partly by the high level of precipitation in October and partly by the mobility of the monovalent Na ions which are leached more easily from the dying leaves during the autumn than at any other time of the vegetation period. Canopy throughfall manifests a lesser degree of Na enrichment than the other elements surveyed previously. All four combinations examined exhibit a similar trend in the changes of Na content in canopy throughfall. Na-concentration in both atmospheric precipitation and canopy throughfall had their maxima in July. The annual development of Na-content of the canopy throughfall in all four combinations shows close similarity.

Manganese

In the investigated period, the Mn-content of atmospheric precipitation was only 0.17 kg/ha, but with throughfall 1.39 kg/ha has reached the soil (Table 1); the greatest amount was found in October (0.318 kg/ha).

The highest enrichment level of Mn was measured in June and July, and again in October and November (enrichment factors between 25 and 70). Enrichment in Mn is probably the result of leaching the leaf tissues (TUKEY, 1970). The development of concentration values is more or less similar to that of the cations discussed so far.

Zinc and iron

Both substances occur only as trace elements in rainwater. Rainwater falling through the foliage was increased in zinc content to a significant measure (e.g. the enrichment factor was higher than 100 in July), but its amount is still very low in throughfall. The same holds for iron. During the entire period of investigation, 0.21 kg/ha Zn and 0.18 kg/ha Fe have reached the forest floor by way of canopy throughfall. On the other hand, atmospheric precipitation has contained 0.13 kg/ha Zn and 0.09 kg/ha Fe (Table 1).

Sulphate–sulphur (SO_4-*S*)

Plants cover a considerable portion of their sulphur requirement from rainwater (OLSEN, 1957; WHITEHEAD, 1964). The ecosystem studied received 17.83 kg/ha SO_4-S during the investigated period, and this amount has signif-

icantly increased by the passage of water through foliage to the soil: 46.07 kg per ha sulphate-sulphur was measured in the throughfall (Table 1). The largest quantities of sulphate-sulphur arrived on the soil in May and October: 13.886 and 13.971 kg/ha, respectively.

The changes in SO_4-S content in canopy throughfall for all four combinations were closely related to the SO_4 ion concentration in atmospheric precipitation. Comparing the combinations, it can be stated that rainwater falling through the foliage of shrubs also scarcely showed a higher level of enrichment. The SO_4-S content is higher for *Qu. petraea* canopy of throughfall than for *Qu. cerris* until August, but this difference disappears later.

The SO_4-S content of rainfall passing through the foliage of the two kinds of trees and shrubs indicates no essential difference.

Concerning the entire period (Fig. 2), it can be stated that the SO_4-S content of throughfall was considerable, especially in the case of *Quercus petraea* + *Cornus mas* (15.06 kg/ha).

Total-nitrogen content

In natural ecosystems, the nitrogen content received through atmospheric precipitation is of especial importance. As already mentioned under "Methods", the KJELDAHL-nitrogen and nitrate-nitrogen content of the water samples was determined and the sum of these two represented the total nitrogen content in the present case. NO_2-N content of the first samples has also been measured, but because of its low presence subsequent measurements have not been made. In the investigated period, 20.09 kg/ha total-N was received by the ecosystem, 17.56 kg/ha organic-N and 2.53 kg/ha NO_3-N. This N-content is significantly higher than that measured by KOZÁK and MÉSZÁROS (1971a) for the 1968—70 mean (14.6 kg/ha/annum). On the other hand, canopy throughfall contained only 17.28 kg/ha, that is 14.95 kg/ha organic-N and 2.33 kg/ha NO_3-N (Table 1).

The quantity of total-N in canopy throughfall was in some cases less than in atmospheric precipitation. This is well illustrated by the curves depicting concentration levels (Fig. 1c), in these instances the enrichment factors were less than 1. Therefore, canopy throughfall was not enriched in N, but rather impoverished. CARLISLE et al. (1966) and NIHLGÅRD (1970) have observed the same phenomenon during their investigations in oak and beech forest. The decrease is primarily describable to the absorption of adsorption of mainly inorganic-N compounds (e.g. nitrate compounds) by the leaf surfaces from the rainwater (STENLID, 1958). Next to the extremely high values of nitrogen in April, the maximum N-concentration of canopy throughfall was measured in May. Enrichment factors were between 2.3—4.8. This increase in May was held only for organic nitrogen with respect to the two N—forms

and it is probably closely related to the caterpillar gradation taking place in May. Analyses of caterpillar excrements indicated that the refuse contained large quantities of organic-nitrogen and that this value was reflected in the May maximum.

Phosphate-phosphorus (PO_4-P)

Atmospheric precipitation contained relatively little quantities of phosphorus: 1.32 kg/ha in the investigation period; canopy throughfall enriched the soil by 2.08 kg/ha (Table 1). The highest enrichment registered for canopy throughfall was measured in May, which, similarly to the nitrogen enrichment, was probably caused by caterpillar gradation since the PO_4-P content of the excrement was also high.

Both atmospheric precipitation and canopy throughfall showed an increase in concentration for July (in the summer enrichment was higher). In November a second enrichment maximum also appeared.

Chlorine

Although it belongs among the macroelements, chlorine plays an insignificant role as a mineral nutrient. In the studied period 12.60 kg/ha chlorine arrived in the ecosystem with rainfall. This quantity, if compared to that in maritime littoral areas (100—200 kg/ha/annum), is insignificant (RAPP, 1969). 12.88 kg/ha chlorine was measured in during the investigation period (Table 1). Consequently, vegetation has not contributed significantly to the increase of Cl-content of rainwater.

The four combinations of precipitation arriving to the soil show similar tendency with respect to change in Cl-content (Fig. 1/c): throughfall of the two shrub species is enriched to a greater degree than canopy throughfall no intercepted by shrub foliage.

Summary

The paper deals with one branch of mineral cycle in the *Quercetum petraeae-cerris* forest ecosystem: the mineral content of canopy throughfall getting into the system as measured for 1974.

We have measured the quantity of eleven elements present in atmospheric precipitation and canopy throughfall. By knowing the amount of precipitation, the concentration levels and canopy density we have computed the amount of the nutrient material present in canopy throughfall that reaches 1 hectare of the forest floor area (February 27 through December 4, 1974): 27.017 kg potassium, 23.28 kg calcium, 4.55 kg magnesium, 1.84 kg natrium,

1.39 kg manganese, 0.21 kg zinc, 0.18 kg iron, 45.07 kg sulphate-sulphur, 17.28 kg total nitrogen, 12.88 kg chlorine and 2.08 kg phosphate-phosphor.

Potassium and sulphur contributes most significanty to the enrichment of canopy throughfall (enrichment maxima were reached in August and November). The extent of enrichment with respect to precipitation was for potassium 1.2—30.1, calcium 1.1—6.4, magnesium 1.1—13.0, manganese 2.2—70.9, sulphur 1.2—8.0, phosphorus 1.4—11.0 fold. Nitrogen and phosphorus enrichment maxima coincide with caterpillar gradation occurring in May.

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Table 1

Bioelement content of rainfall and throughfall in an oak-forest (Quercetum petraeae-cerris). (27 Febr.—4 Dec., 1974) — in kg/ha

A = precipitation; B = throughfall (1 = *Quercus petraea*; 2 = *Qu. cerris*; 3 = *Qu. petraea* + *Acer campestre*; 4 = *Qu. petraea* + *Cornus mas*); B(1—4)—A = Difference between throughfall and rainfall; a = bioelement content in kg/ha; b = enriching factor $\left[\frac{\text{element concentration of throughfall in mg/l}}{\text{element concentration of rainfall in mg/l}}\right]$; n.a. = not analysed

Date	Rainfall type	Rainfall quantity, mm	K		Ca		Mg		Na		Mn		Zn		Fe		SO_4—S		Total-N		Cl		PO_4—P	
			a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b
27. II—13. III	A	4.3	0.044		0.210		0.022		0.016		0.004		0.0013		0.0014		0.329		0.182		0.163		0.0175	
	B-1		0.018	1.5	0.078	1.3	0.009	1.4	0.009	2.2	0.003	2.9	0.0006	1.7	0.0011	3.0	0.131	1.4	0.073	1.5	0.039	0.8	0.0047	2.3
	B-2	3.6	0.011	1.8	0.045	1.5	0.005	1.5	0.007	3.3	0.002	3.1	0.0003	1.4	0.0005	2.7	0.072	1.5	0.042	1.6	0.023	1.0	0.0023	2.1
	B-3		0.014	1.6	0.053	1.3	0.005	1.3	0.005	1.5	0.002	2.8	0.0002	1.1	0.0006	2.3	0.098	1.6	0.061	1.8	0.029	0.9	0.0036	2.5
	B-4		0.011	1.2	0.064	1.1	0.005	1.2	0.005	1.5	0.002	2.2	0.0003	1.0	0.0009	3.1	0.080	1.2	0.059	1.6	0.028	0.8	0.0021	2.0
	B(1—4) — A	— 0.7	+0.010		+0.030		+0.002		+0.010		+0.005		+0.0001		+0.0017		+0.052		+0.053		—0.044		+0.0062	
13. III—24. IV	A	3.3	0.083		0.360		0.047		0.018		0.003		0.0009		0.0002		0.517		0.300				0.0113	
	B-1		0.089	9.8	0.129	2.7	0.026	5.2	0.006	2.1	0.007	18.9	0.0006	4.3	0.0007	31.4	0.148	1.5	0.097	1.7			0.0127	5.8
	B-2	1.4	0.027	2.4	0.069	1.4	0.012	1.6	0.002	1.2	0.002	4.4	0.0002	1.4	0.0002	6.0	0.057	0.8	0.032	0.8	n.a.		0.0021	1.4
	B-3		0.047	13.0	0.086	4.0	0.017	7.8	0.003	2.3	0.003	16.3	0.0003	4.4	0.0004	27.3	0.146	2.6	0.075	2.3			0.0075	6.2
	B-4		0.059	10.5	0.091	2.9	0.018	5.6	0.004	2.4	0.005	18.9	0.0004	4.8	0.0004	27.0	0.163	3.9	0.081	3.1			0.0093	9.7
	B(1—4) — A	— 1.9	+0.139		+0.015		+0.026		—0.003		+0.014		+0.0006		+0.0015		—0.003		—0.015				+0.0203	
24. IV—22. V	A	78.6	1.320		1.359		0.110		0.369		0.079		0.0212		0.0078		4.027		2.227		1.616		0.1439	
	B-1		2.016	8.9	0.517	2.4	0.174	9.3	0.188	2.9	0.089	6.8	0.0071	1.9	0.0121	8.4	3.954	5.7	1.308	3.4	0.646	2.3	0.1681	7.1
	B-2	60.9	0.638	4.1	0.243	1.4	0.078	5.9	0.136	3.3	0.033	3.4	0.0045	1.7	0.0050	5.6	1.750	3.6	0.800	3.1	0.384	1.9	0.0497	2.9
	B-3		2.126	11.5	0.575	3.0	0.183	11.9	0.111	2.1	0.092	8.4	0.0058	1.9	0.0103	9.3	4.555	8.0	1.507	4.8	0.610	2.6	0.1929	9.6
	B-4		1.780	9.3	0.404	2.0	0.147	9.2	0.161	3.0	0.095	8.4	0.0065	2.1	0.0094	8.3	3.627	6.2	0.739	2.3	0.519	2.2	0.2312	11.0
	B(1—4) — A	—17.7	+5.240		+0.380		+0.470		+0.227		+0.230		+0.0027		+0.0290		+9.859		+2.127		+0.543		+0.4981	
22. V—19. VI	A	104.6	4.182		1.589		0.167		0.261		0.010		0.0366		0.0523		2.214		2.084		2.149		0.1150	
	B-1		2.917	3.6	0.808	2.6	0.218	6.7	0.090	1.8	0.088	43.6	0.0206	2.9	0.0275	2.8	1.746	4.1	0.731	1.8	0.838	2.0	0.0696	3.1
	B-2	81.0	0.660	1.4	0.310	1.8	0.094	5.1	0.036	1.2	0.046	40.7	0.0111	3.1	0.0066	1.0	1.203	4.9	0.176	0.7	0.292	1.2	0.0277	2.3
	B-3		1.557	2.6	0.623	2.6	0.153	6.3	0.073	1.8	0.072	48.3	0.0130	2.4	0.0302	3.8	1.632	5.0	0.410	1.3	0.553	1.7	0.0396	2.4
	B-4		1.648	2.5	0.567	2.3	0.307	13.0	0.063	1.6	0.055	33.7	0.0203	3.6	0.0135	1.7	0.941	2.7	0.474	1.4	0.471	1.4	0.0547	3.0
	B(1—4) — A	—23.6	+2.600		+0.719		+0.605		+0.001		+0.251		+0.0284		+0.0255		+3.308		—0.293		+0.005		+0.0766	
19. VI—31. VII	A	40.3	0.397		2.383		0.401		0.167		0.008		0.0004		0.0039		3.104		1.057		1.098		0.2712	
	B-1		1.250	17.2	1.074	2.4	0.281	3.8	0.077	2.5	0.037	25.7	0.0116	164.0	0.0097	13.6	1.181	2.0	0.354	1.8	0.430	2.1	0.0574	1.1
	B-2	27.1	0.516	12.6	0.527	2.1	0.148	3.5	0.054	3.0	0.023	28.0	0.0045	108.0	0.0036	8.3	0.508	1.5	0.141	1.2	0.365	3.1	0.0170	0.6
	B-3		0.860	19.6	0.759	3.0	0.153	3.7	0.041	2.0	0.029	35.1	0.0088	217.0	0.0084	19.0	0.643	1.9	0.310	2.5	0.332	2.4	0.0402	1.1
	B-4		0.825	15.8	1.557	5.1	0.294	5.8	0.047	2.2	0.017	16.1	0.0023	48.0	0.0030	6.0	0.644	1.6	0.354	2.6	0.393	2.8	0.0678	1.9
	B(1—4) — A	—13.2	+3.054		+1.534		+0.475		+0.052		+0.098		+0.0268		+0.0208		—0.128		+0.102		+0.422		—0.0887	
31. VII—29. VIII	A	90.1	0.135		2.477		0.207		0.090		0.018		0.0045		0.0180		2.975		5.622		1.501		0.3064	
	B-1		0.582	25.0	1.741	4.0	0.311	8.6	0.059	3.8	0.020	6.4	0.0051	6.6	0.0100	3.2	0.802	1.5	0.940	0.9	0.465	1.8	0.0693	1.3
	B-2	64.9	0.361	23.9	1.027	3.4	0.153	6.0	0.028	2.7	0.016	7.5	0.0054	10.0	0.0082	4.0	0.490	1.4	0.447	0.7	0.290	1.7	0.0594	1.8
	B-3		0.495	30.1	1.352	4.0	0.263	10.2	0.039	3.4	0.024	11.3	0.0056	9.6	0.0079	3.5	0.517	1.4	0.624	0.9	0.315	1.6	0.0684	1.8
	B-4		0.514	26.7	2.251	6.4	0.156	5.2	0.061	4.7	0.028	11.0	0.0060	9.2	0.0082	3.2	0.589	1.4	0.761	0.9	0.370	1.7	0.0948	2.1
	B(1—4) — A	—25.2	+1.817		+3.894		+0.676		+0.097		+0.070		+0.0176		+0.0163		—0.577		—2.850		—0.061		—0.0145	
29. VIII—2. X	A	52.9	0.211		1.058		0.095		0.217		0.026		0.0265		0.0106		1.771		2.696		1.208		0.1775	
	B-1		0.474	12.4	0.574	2.9	0.081	4.5	0.063	1.5	0.043	8.6	0.0051	1.0	0.0028	1.4	1.068	3.6	0.625	1.2	0.522	2.3	0.0578	1.7
	B-2	38.7	0.341	14.5	0.366	3.0	0.055	4.9	0.039	1.6	0.031	10.4	0.0045	1.4	0.0010	0.8	0.756	3.8	0.365	1.2	0.297	2.2	0.0502	2.6
	B-3		0.385	14.0	0.711	4.7	0.093	7.0	0.043	1.4	0.035	10.3	0.0042	1.2	0.0025	1.8	0.938	4.1	0.448	1.2	0.425	2.6	0.0334	1.4
	B-4		0.427	14.4	0.706	4.8	0.097	7.3	0.045	1.4	0.029	7.8	0.0041	1.1	0.0017	1.1	1.158	4.6	0.452	1.1	0.423	2.5	0.0386	1.5
	B(1—4) — A	—14.2	+1.416		+1.299		+0.231		—0.027		+0.112		—0.0086		—0.0026		+2.149		—0.806		+0.459		+0.0025	
2. X—30. X	A	194.0	0.992		7.146		1.211		0.258		0.020		0.0238		0.0		1.942		5.028		4.533		0.2717	
	B-1		1.480	8.2	1.430	1.1	0.254	1.1	0.081	1.6	0.092	24.4	0.0106	2.3	0.0		2.768	7.7	1.156	1.2	0.873	1.0	0.1130	2.2
	B-2	157.5	0.697	5.3	0.493	0.5	0.076	0.5	0.051	1.5	0.059	23.0	0.0069	2.2	0.0		1.652	6.4	0.650	1.0	0.401	0.6	0.0511	1.4
	B-3		1.373	8.8	0.992	0.8	0.179	0.9	0.060	1.4	0.099	32.0	0.0102	2.5	0.0		2.507	7.7	0.992	1.1	0.952	1.2	0.1099	2.6
	B-4		1.705	10.5	1.442	1.2	0.314	1.5	0.055	1.2	0.068	20.0	0.0105	2.6	0.0		7.044	22.0	0.995	1.2	1.004	1.3	0.1721	3.9
	B(1—4) — A	—36.5	+4.263		—2.789		—0.388		—0.011		+0.298		+0.0144				+12.029		—1.235		—1.303		+0.1744	
30. X—4. XII	A	27.1	0.070		0.818		0.048		0.068		0.004		0.0143		0.0		0.956		0.900		0.361		0.0200	
	B-1		0.332	23.1	0.494	3.0	0.063	6.5	0.046	3.3	0.048	64.8	0.0034	1.2	0.0		0.820	4.2	0.353	1.9	0.174	2.3	0.0300	7.2
	B-2	23.3	0.239	27.8	0.470	2.3	0.030	5.1	0.014	1.7	0.033	70.9	0.0020	1.2	0.0		0.444	3.8	0.150	1.3	0.107	2.4	0.0120	4.9
	B-3		0.222	21.5	0.309	2.6	0.037	5.3	0.016	1.7	0.029	53.8	0.0025	1.2	0.0		0.514	3.8	0.231	1.7	0.115	2.1	0.0130	4.6
	B-4		0.321	24.5	0.334	2.2	0.057	6.7	0.024	1.9	0.035	45.9	0.0021	0.7	0.0		0.813	4.4	0.267	1.6	0.202	2.9	0.0380	9.5
	B(1—4) — A	— 3.8	+1.044		+0.789		+0.139		+0.032		+0.141		—0.0043				+1.635		+0.101		+0.237		+0.0730	
Σ 27. II—4. XII	A	595.3	7.430		17.40		2.31		1.46		0.17		0.13		0.09		17.83		20.09		12.62		1.32	
	B(1—4)	456.6	27.017		23.28		4.55		1.84		1.39		0.21		0.18		46.07		17.28		12.88		2.08	
	B(1—4) — A	—138.7	+19.587		+5.88		+2.24		+0.38		+1.22		+0.08		+0.09		+28.24		—2.82		+0.26		+0.76	

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ELIMINATION OF CHROMOSOMES IN AN ALLOPLOID HYBRID OF NICOTIANA TABACUM × N. GLAUCA

By

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Cytogenetic studies were carried out on alloploid hybrid progenies of *Nicotiana tabacum* (Kentucky) × *N. glauca*. The first hybrid generation was morphologically intermedier with regular meiosis ($n = 36_{II}$). In the F_2—F_4 generations considerable segregation was observed in spite of the alloploid condition. White flowered plants were selected in the fourth generation, which were stabilized in F_5 and showed $2n = 48$, $n = 24$ chromosome number instead of $2n = 72$, $n = 36$ as the F_1. The karyotype analyses of the plants with decreased chromsome number suggest that the missing 12 chromosome pairs belong to one (possibly T) or both (ST) genomes of *N. tabacum*.

Introduction

Within the genus *Nicotiana* hybrids can be readily formed between taxonomically remote species, but these hybrids usually show a high degree of pollen sterility. Fertile amphidiploids or alloploids can be raised by crossing autotetraploid derivatives of species.

There are hundreds of diploid and polyploid *Nicotiana* hybrids published so far. In a previous paper we also gave an account of hybrids produced artificially (SZILÁGYI, 1970). These alloploid hybrids are usually fertile, but (unlike the true amphidiploids) because of the occurence of homoeologue bivalent formation (autosyndesis) there is some segregation in their progeny.

Selective elimination of certain genomes has already been reported in the literature. As an example, in the heptaploid hybrid of *Triticale* (8x) × *Triticale* (6x) ($2n = 7x = 49$; genomic formula AABBDSS) the whole "D" genome is often lost (KISS, 1966). Selective elimination of certain genomes has also been used to produce haploid plants (SUBRAHANYAM and KASHA, 1973). The present article reports on the chromosome elimination in an alloploid derivative of the *N. tabacum* (Kentucky) × *N. glauca* cross.

Materials and methods

The *Nicotiana tabacum* (Kentucky) × *N. glauca* alloploid ($2n = 72$) was produced in 1968. The hybridization programme started with an inbred line of *N. tabacum* "Kentucky" ($2n = 48$) and the wild species *N. glauca* ($2n = 24$), raised from seeds of a botanical garden. 0.5 per cent

colchicine solution was applied to obtain autopolyploids (2n = 96 and 48, respectively), and these were crossed to get the fertile alloploid. The progeny was grown up in the greenhouse and experimental garden of the Institute of Genetics (HAS), Budapest.

Meiotic and mitotic preparations were made with the standard acetocarmine method. For the karyotype analysis, a pretreatment with 0.2 per cent colchicine was applied for 2.5 hours. Pollen fertility was judged by the proportion of stainable (acetocarmine) pollen (1500 counts from each sample). Microphotographs were taken with MF Zeiss, set up on an NFpK Zeiss research microscope.

Results

1. The morphology of the *N. tabacum* (Kentucky) × *N. glauca* F_1 alloploid was intermedier (Fig. 14). Its meiosis was fairly regular, showing 36 bivalents at metaphase I, and occasionally 1—3 quadrivalents (Fig. 1), resulting in 46% fertile pollen grains.

2. Among the F_2 progenies, morphologically different types were found. They were classified into two main groups, one was approaching *N. tabacum* (Figs 16 and 17), the other was characterized by a flower similar to *N. glauca* (Fig. 15). In the first group we observed 16 per cent pollen fertility, while the second group was more fertile with 41 per cent of stainable pollen. The low fertility of the *N. tabacum*-like plants was paralleled by the irregularities observed at meiosis. 2—4 univalents were often found at metaphase I. (Fig. 2) and sometimes a formation of chromosome bridge was also visible (Fig. 3). The meiosis of glauca-type plants, on the other hand, was regular with 36 bivalents at metaphase I.

3. Analysing the F_3 generation, we noticed that the plants resembling *N. glauca* morphologically and cytologically have been stabilized (n = 36 bivalents at meiosis; Fig. 8). On the contrary, the *N. tabacum*-like plants segregated further, and among them we sorted out plants with decreased chromosome number (n = 30, n = 24, respectively; Figs 9 and 10). Beside the commonly found meiotic chromosome number (30, 24) in these plants, some pollen mother cells exhibited as low as 10, 6, 4 and even 2 bivalents only (Figs 4—7). These abnormally low chromosome-numbered cells were eliminated during pollen maturation. The number of multivalents was generally very low, maximum $0—3_{IV}$.

4. The selected *tabacum*-like plants of n = 24 chromosome number of F_3 were uniform. One of them produced five white-flowered plants in the F_4 generation. These white-flowered plants (n = 24) had 22 per cent of fertile pollen.

5. The next progeny (F_5) raised from the plants of white flower gave uniformly white-flowered plants with 24_{II} bivalents at meiosis.

In the F_1 hybrids as well as in the plants of later generations of the same chromosome number, the separation of certain genomes in mitotic and meiotic metaphases was clearly visible (Figs 11, 12 and 13).

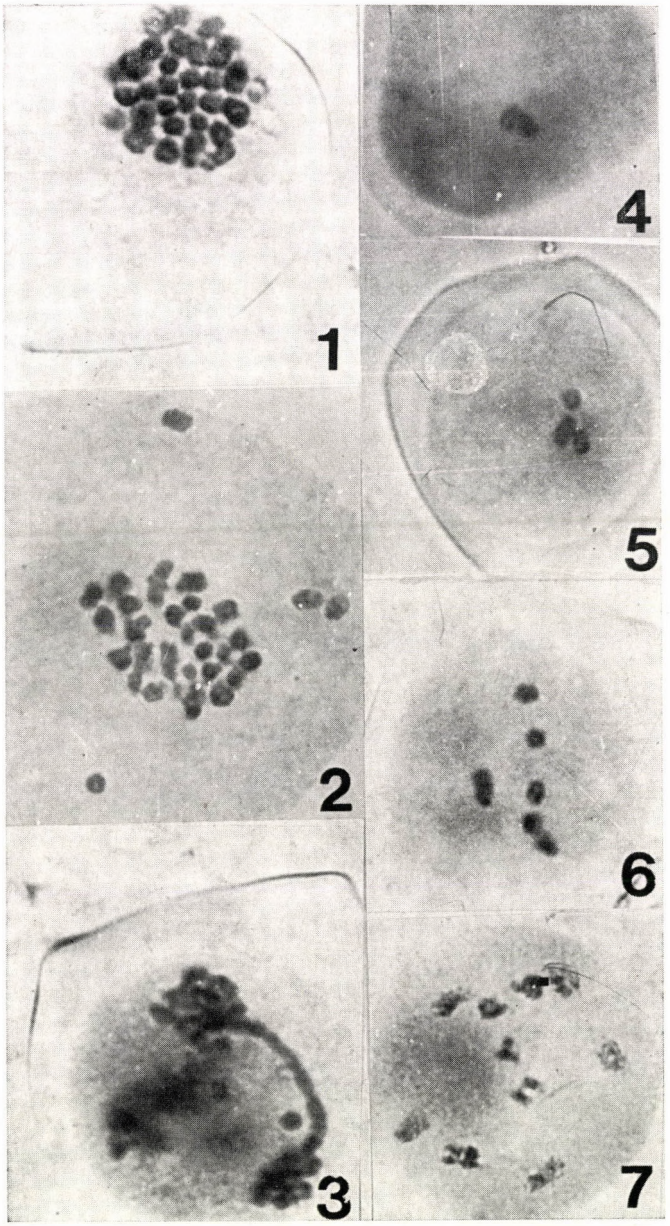


Fig. 1. Meiosis of the F_1 alloploid of *Nicotiana tabacum* (Kentucky)$\times$ *N. glauca* showing 36 bivalents ($\times$800)
Fig. 2. Meiosis in the F_2 generation showing 4 univalents and 34 bivalents ($\times$800)
Fig. 3. Chromosome bridge in an F_2 plant ($\times$800)
Figs 4—7. Meiosis in the F_3 generation of the *N. tabacum* (Kentucky)$\times$ *N. glauca* alloploid showing decreased numbers of chromosomes (bivalents) ($\times$800)

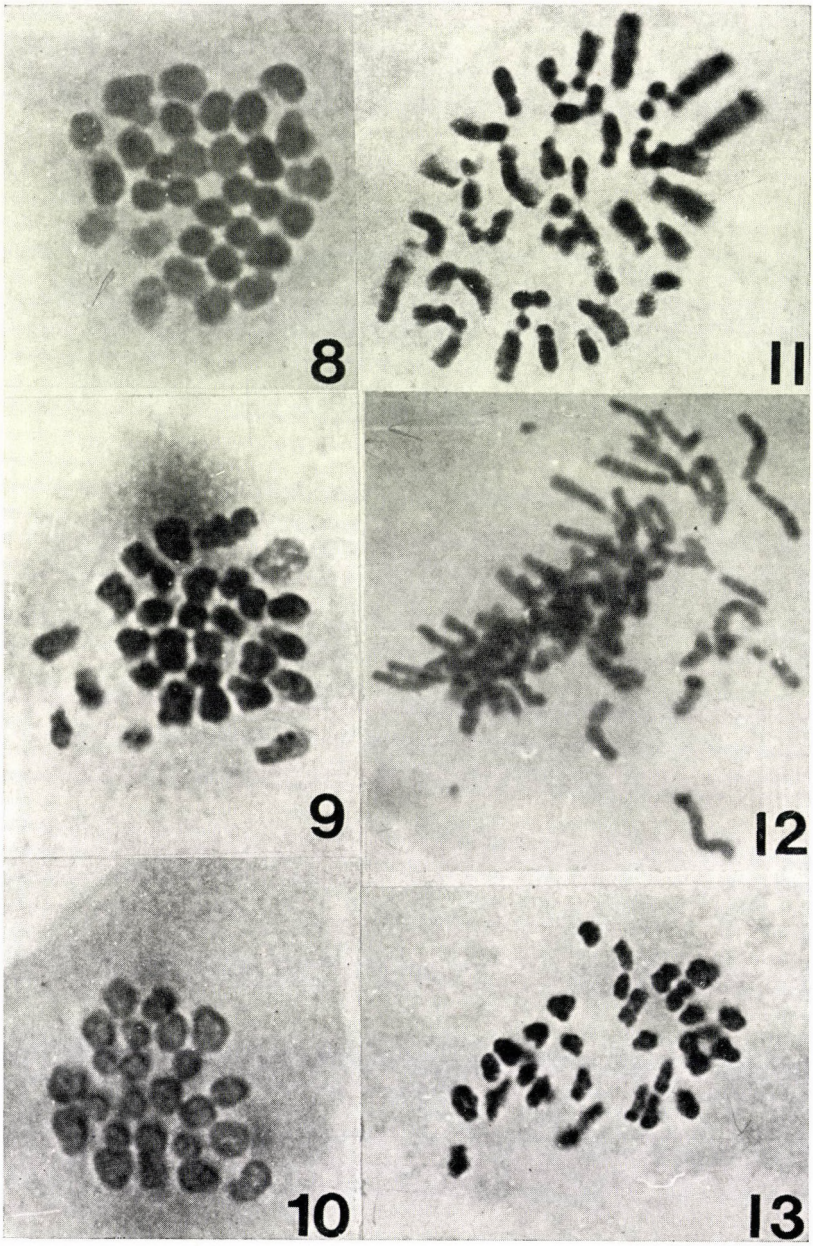


Fig. 8. Meiosis of the "glauca" type progeny showing 36 bivalents (×1000)
Figs 9, 10. Meiosis of the plants with decreased chromosome number (×1000)
Fig. 11. Mitosis of the diploid hybrid *N. tabacum* (Kentucky)×*N. glauca* showing 2n = 36 (×1000)
Fig. 12. Mitosis of the alloploid hybrid *N. tabacum* (Kentucky)×*N. glauca* showing some degree of genomic separation (×1000)
Fig. 13. Meiosis in the same alloploid plant with a tendency of genome separation (×800)

Fig. 14. Alloploid F_1 plant of *N. tabacum* (Kentucky) × *N. glauca*
Fig. 15. Glauca type segregant in the F_3 generation of the alloploid

In order to identify the eliminated chromosomes, karyotype analysis was done on the 2n = 48 plants and this was compared with the known karyotypes of both *N. glauca* and *N. tabacum*. According to KOSTOFF (1943) and GOODSPEED (1954), the chromosomes of *N. glauca* are larger and their morphology is also characteristically distinct. The *N. glauca* karyotype consists of 1 metacentric, 1 submetacentric and 10 acrocentric pairs of chromosomes. On the other hand, *N. tabacum* has 10 metacentric, 5 submetacentric plus 9 acrocentric chromosome pairs.

In the identification of chromosomes in the karyotype of *N. tabacum* × *N. glauca* alloploid progeny with decreased chromosome number (2n = 48) (Fig. 18), we took advantage of the association of chromosomes of the same genome. A similar chromosome arrangement has been found in other plants too (HENEEN, 1962; FELDMAN, 1966).

In the hybrid with decreased chromosome number there were only four pairs of metacentric chromosomes, thus 7 pairs were missing in this category.

Figs 16—17. Tabacum type segregants in the F_3 generation of the alloploid

Similarly only four pairs of submetacentric but 16 pairs of acrocentric chromosomes were observed, meaning that 2 pairs of submetacentric and 3 pairs of acrocentric chromosomes were lost. In the meantime, large chromosomes of possibly *N. glauca* origin were present (Fig. 18: first 2 pairs in group a and b; first 10 pairs of group c).

Discussion

Cytogenetic analyses of several diploid interspecific *Nicotiana* hybrids pointed out the genetical relatedness of the species. This is reflected in the presence of bivalents in the diploid F_1 hybrid, but because of preferential pairing the quadrivalent formation is rare in their allotetraploid derivatives. Thus, many alloploids show diploid-like meiosis (KEHR and SMITH, 1952). A maximum of 6—8 bivalents was observed by KOSTOFF (1943) and GOODSPEED (1954) in the interspecific hybrid of *N. tabacum* × *N. glutinosa*, while in their alloploid there was no multivalent at all, and the whole meiotic process was fully regular. Similarly, KEHR and SMITH (1952) reported on a high degree of chromosome pairing (9—10 bivalents) in the *N. tabacum* × *N. glauca* diploid hybrid, but the multivalent frequency at the alloploid level was found to be unexpectedly low ($0—3_{IV}$) which is the same as our data.

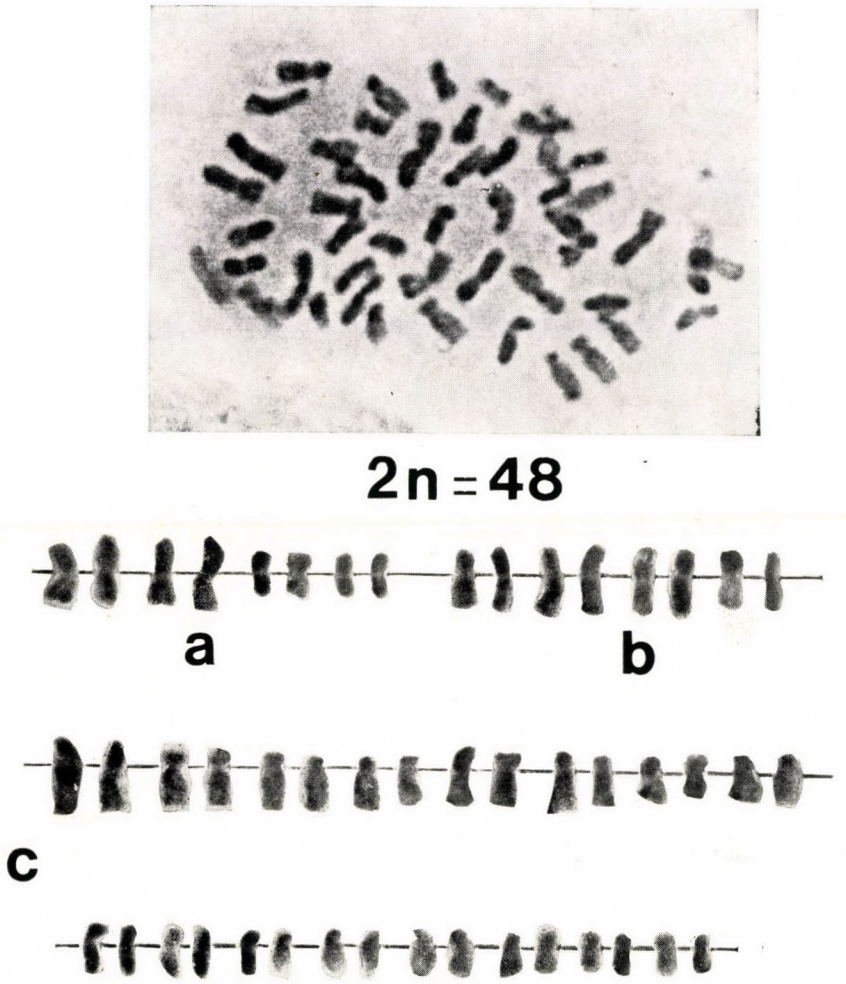


Fig. 18. Karyotype of the *N. tabacum* (Kentucky) × *N. glauca* alloploid, a) metacentric; b) submetacentric; c) acrocentric chromosomes (×800)

Our previous observations on interspecific crosses between *Nicotiana* species with 2n = 24 chromosome number revealed the high stability of their alloploid derivatives even after the fourth generation. The hybrid described in this paper is, however, different, because one of the parents is already of alloploid origin (*N. tabacum*). Thus the polyploid derivative of our *N. tabacum* × *N. glauca* hybrid corresponds to the hexaploid (allohexaploid) level based on x = 12.

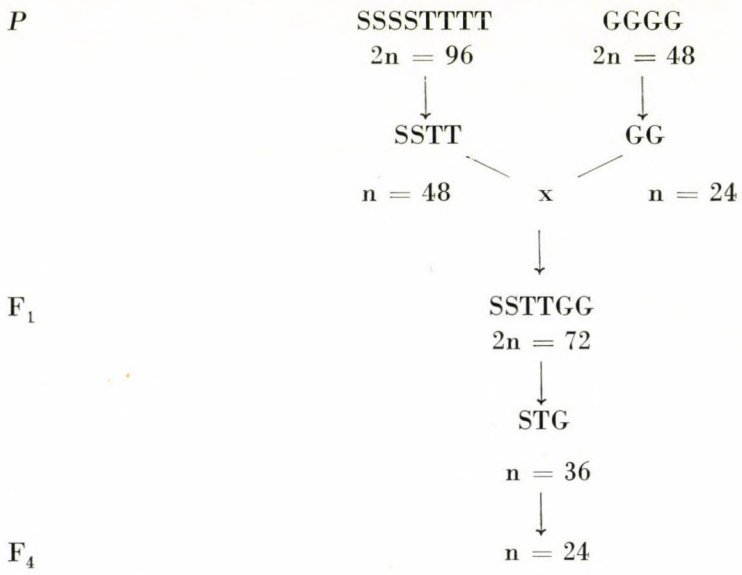
In F_2 generation there was a characteristic segregation (in spite of the polyploid level), and stabile lines were isolated only at the fourth–fifth generations. Segregation in the alloploid (involving *N. tabacum*) F_2, F_3 generations

has already been reported by SMITH et al. (1953). These authors produced a multiple alloploid of *N. bigelovii*, *N. debneyi* and *N. tabacum*. All three species are believed to be of alloploid origin. Among the selfed progeny of the hybrid, three morphologically distinct lines were separated, which were proven to be stable in later generations. According to the cytological analysis, these were all of decreased chromosome number, n = 57, n = 56, 52 and 51 as compared with the 2n = 144 F_1 plants.

The elimination of the whole *N. plumbaginifolia* genome in *N. tabacum* × *N. plumbaginifolia* hybrid is also known (DAVIES, 1974).

Considering the results of our experiment, we may symbolize the genome composition of the hybrids observed as follows:

(*N. tabacum*-SSTT, being an allotetraploid)



S = *N. silvestris*; T = *N. tomentosiformis*; G = *N. glauca*

The origin of n = 24 from n = 36 can be explained by the elimination 12 chromosomes from the complete STG genome. The simplest case would be the loss of a whole genome (as in the 7x *Triticale* already mentioned) each consisting of 12 chromosomes.

The pink-white flower colour change accompanying the n = 36 → 24 transition suggests that if whole genome elimination was involved the missing genome should have been that of pink-flowered *N. tomentosiformis*.

The karyotype analysis of the n = 24 chromosome-numbered plants (Fig. 18) points to the same direction. According to our observations, all the

large *N. glauca* chromosomes are present in the n = 24 plants. On the other hand, the eliminated 7 metacentric, 2 submetacentric and 3 acrocentric chromosome pairs are members of the *N. tabacum* karyotype which is known to consist of ancestral genomes of *N. silvestris* and *N. tomentosiformis*.

An alternative explanation would be that the 12 missing chromosomes do not represent a whole genome, but rather a mixture of *N. tabacum* chromosomes from the S and T genomes. Further crossing experiments (involving hybridization with synthetic SSGG = *N. silvestris* × *N. glauca* allotetraploid) are in progress to clarify this ambiguity.

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THE ARCHITECTURE AND THE QUANTITATIVE INVESTIGATION OF SOME CHARACTERISTICS OF ANISE, PIMPINELLA ANISUM L.

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Authors adopt and re-interpret DEVADES and BECK's (1971) architecture instead of the inadequately defined morphological concept, for a better approach of the spatial arrangement proportions and function of organs construing the plant.

At a given time, organs — architectural elements — in various stages of development, weight and surface capable for assimilation are found on the plant.

The length value distribution of internodes building up the main axe may be characterized in species of a limited growth with the general MITSCHERLICH S-shaped curve.

The length of petioles of basal and stem leaves is described by a parabole.

The dry weight and assimilating surface area per internode are only partially parallel in value with each other. Even at the beginning of the flowering of the main umbel, the greatest proportion of weight is yielded by the primary inflorescence axis together with the main umbel and the side shoots and the leaves.

There is no significant, linear correlation between the dry weight of height and the assimilating surface area per vertical zones.

These results indicate that the surfaces producing organic matter and the place of accumulation happen in different points of the plant.

Introduction

The length values of the diverse organs (primarily of the internodes) during growth or on the fully developed plant were measured and partly interpreted by GRIESEBACH (1843), to establish the intercalar growth of *Astrantia major*; by TROLL (1937) and KOVÁTS (1973), to describe more exactly (with reference to the longitudinal values of the main and lateral axes per internode). The morphology of several other species; by WESSELY (1960), BARÁTH—MÁTHÉ jr., MÁTHÉ (1973), to solve taxonomic problems in *Solanum* species.

Nowaday, the morphological analysis of the complex architecture* for the plant kingdom as follows: "Architecture is the aspect of morphology

* The term architecture, as defined by WEBSTER's "New International Dictionary" (cf. HICKEY, l.c.), was adopted by DEVADES and BECK (1971).

which applies to the spatial configuration and coordination of those elements making up part of a plant without regard to histology, function, origin, or homology" (cf. HICKEY).

Characterizing also the *Umbelliferae*, with due respect also to internodial length values, together with the observations concerning the partially correlated distribution conditions between assimilating surface and weight are wanting in literature.

Following DEVADES and BECK's concept, plant architecture is given by the proportionate spatial arrangement and coordination of organs as architectural elements, modified for special functions and thereby reflecting in their proportions also environmental conditions.

The architecture of anise is built up of the following elements: tap-root, main axis and side shoots divided into internodes various lengths, leaves of different surface areas and shapes, and the epigynous, androgyne flowers arranged into umbels and umbellets. The epigeous elements of the plant are arranged along a spiral axis, within which the beginning and termination points of one-third of the period are marked by the nodes, and by the elements (organs) issuing from these points.

Starting from the general characterization of the architecture the quantitative investigation of differences appearing qualitatively between the given one-third periods i. e. the internodes assumed primary importance. Secondly our aim was to measure the distribution of the dry weight (s. l. production) and of the assimilating area, in the same system.

Material and method

On the basis of qualitative description and of intuition springing from observation, as a preliminary study the following measurements and calculations have been carried out (on five examplars sown on the 26th of March, 1973, and collected on the 19th of July, 1973, in which the foliage was of completely developed size, the petals were closed in the inflorescence of the main umbel the side shoots have not reached, or only scarcely surpassed the height of the main axis, their inflorescences were green and the umbellet was in a closed state): defining the internode above the root as No. 1, the length of each internode was measured, the length of petioles arising on nodes No. 1, 2, 3, etc. of the side shoots of the secondary and tertiary inflorescence axes (in mm). Subsequently, the exemplare have been cut per internode. Accordingly, one investigated object consisted of several elements, i. e. the leaf (in the first case: leaves) inserting from the node, the side shoot (at the highest node often two side shoots), and the internode itself.*

* The chlorenchyma layer of the main axis consists of plasts containing cells similar in shape to those in the parenchyma of the leaves. In the plasts of the chlorenchyma of the main axis also assimilated starch was observed. Therefore we also considered half of the cylinder-jacket of the shoot axes as an area of assimilation. The other half of the cylinder-jacket is composed of collenchyma for strengthening purposes, which appears as a rib on the surface and which does not contain plasts. (The assimilating activity of the chlorenchyma of lignifying shoot axes has been already shown by SZUJKÓ-LACZA—FEKETE—FALUDI—DÁNIEL 1971; SZUJKÓ-LACZA—RAKOVÁN—FEKETE—HORVÁTH 1972.)

On the basis of the averaged values of the five exemplars, we thereafter established the s. l. internodially assimilating surface area and dry weight. The assimilating surface area was measured by light planimeter (cf. MEDINA—LIETH, 1964), in the sequence of internodia, on fresh material, the dry matter weight was measured on material dried at 80 °C. Following the internodial surface area determination, the surface area of the leaves was calculated also separately. Between the dry weight and assimilating surface area per internode, we calculated a linear correlation according to SVÁB (1967).

Results and discussion

It may be established on the basis of the first column of Table 1, that the s. str. lower internodes are shorter. Internodes 3, 4, 5, and 6 are of nearly equal length and longer than the lower ones. The longest internode is No. 8,

Table 1

The numerical data of the architecture and architectural elements of Pimpinella anisum L., and the conditions of assimilating surface and of weight distribution

	Length in cm								Assimilating surface in cm²			Weight in g
	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.
Serial no. of internode	length zone	cumulated length	length of petiole	length of side shoot	stem	internode leaf, side shoot*	side shoot (stem + leaf)	5 + 6 + 7	main umbel	total side umbels	8 + 9 + 10	
3rd i.a.	2.0	36.4										
2nd i.a.	3.1	34.4							1.8	6.0	7.8	0.9
8.	5.0	31.3	1.3	9.1	3.2	4.4	3.1	10.1			10.7	0.3
7.	4.2	26.3	1.3	14.2	3.1	2.0	2.5	6.2			7.6	0.2
6.	4.1	22.1	1.4	17.8	3.4	6.4	4.8	14.6			14.6	0.3
5.	4.2	18.0	1.6	19.9	3.6	6.7	6.2	16.5			16.5	0.5
4.	4.1	14.0	2.1	20.3	3.8	9.2	6.4	19.4			19.4	0.5
3.	3.9	9.9	3.1	23.7	4.1	10.2	5.7	20.0			20.0	0.5
2.	3.2	6.0	4.5		3.6	10.0		13.6			13.6	0.2
1.	2.8	2.8	4.1		2.0	8.2		10.2			10.2	0.3
			3.2									
			2.9									
	$\Sigma =$			$\Sigma =$	$\Sigma =$	$\Sigma =$	$\Sigma =$	$\Sigma =$	$\Sigma =$		$\Sigma =$	$\Sigma =$
	36.4			105.0	26.8	57.1	28.7	112.6	7.8		120.4	4.6
					$\approx 1/4$	$\approx 1/2$	$\approx 1/4$					0.9**

* = internode + leaf + side shoot; ** = weight of root; i.a. = inflorescence axis

concomitantly also the primary inflorescence axis of the main umbel. Between the basal leaves the length of petioles increases from the 1st to the 3rd, and the 4th petiole, arising on the 2nd node is the longest among all stem leaves. From here upward, the length of petioles decreases, and those of the 5th, 6th, 7th and 8th are short, scarcely differing in length from each other.

At this stage of development, the centre of the assimilating surface is on the 3rd and 4th internodes. (Concerning weight and assimilating surfaces, the term internode is used *sensu lato* in other words, it comprises side shoots, leaves, etc. !). According to the data of the 4th column and the morphological description, these two internodes have also the longest side shoots.

More than half of the total assimilating surface of the plant is represented by the stem leaves, and nearly one-quarter is ascribable, separately, to the surface of the main axis and of the side shoots. (In the latter, we did not measure the relatives small and few leaves developing on them.)

The weight distribution conditions of the plant show a partial correlation with the distribution of the assimilating surfaces. Though there are exceptions, e.g. level 9, which comprises the secondary and tertiary inflorescence axes of the main umbel, the carpell primordia, and the weight of side umbels emitted from the same node. The greatest weight proportion occurs here already at this stage of development. The side shoots of nodes 3, 4, and 5 are excel as far as assimilating surface is concerned.

Table 2 contains data referring to the main umbel. At this stage, the, inflorescence axes have a total length of 8 cm and weight 0.5 g. (On the average the main umbel has about 120 flowers, representing 240 shysocarp primordia.)

Table 3 gives numerical characteristics of specimen having 6 side shoots on the average (though at this stage the side shoots have not yet reached their fully developed state). The side shoots, inserted from nodes 3, 4 and 5, com-

Table 2

Data of the 1st, 2nd and 3rd order inflorescence axes of the main umbel

	Length (cm)	Diam. (cm)	Pieces	Assimilating surface (cm^2)	Weight (g)
I. i.a.	5.0	2	1	3.2	0.3
II. i.a.	2.5	0.4	12	1.2	0.2*
III. i.a.	0.5	0.1	10**	0.6	
	$\Sigma =$ 8.0			$\Sigma =$ 5.0	$\Sigma =$ 0.5

* = without flowers; ** = average of every 2nd i.a.

Table 3

Data of an average side shoot

Serial no.	On which node	Length (cm)	Length of 1st internode (cm)	Length of 2nd internode (cm)	Length of 1st i.a. (cm)	Length of 2nd i.a. (cm)	Length of 3rd i.a. (cm)	Assimilating surface (cm^2)
6.	8	9.1	6.5					2.5
5.	7	14.2	11.5					3.1
4.	6	17.8	10.8	4.6				4.8
3.	5	19.9	12.1	4.8	2.1	1.7	0.3	6.2
2.	4	20.3	11.1	5.2				6.4
1.	3	23.7	10.9	7.8				5.7

prise 2 internodes and the primary, secondary and tertiary inflorescence axes; in the case of nodes 7 and 8, the number of internodes is frequently merely one.

The first and 2nd nodes only rarely bear side shoots; when present, they are rather rudimentary. Within a population comprising a large number of specimens, it happens sometimes that the main axis is rudimentary, in such cases the side shoots of the lower node are much more developed (examples of basally ramifying plants).

Among the side shoots which are fully developed and which have reached their entire length the longest ones are on node 5. In the not fully developed ones, the longest shoots arise on node 3 (Table 3).

Table 4 contains the data of an average side shoot. In this stage of development, the primary, secondary and tertiary inflorescence axes are only half as long and half as much in weight as the main umbel. On the other hand, the number of the tertiary inflorescence axes is higher than of those developed on the main umbel.

Table 4

Data of the 1st, 2nd and 3rd order inflorescence axes an average side umbel

	Length (cm)	Diam. (mm)	Pieces	Assimilating surface (cm^2)	Weight (g)
1st i.a.	2.1	1.5	1	2.3	0.1
2nd i.a.	1.7	0.3	10	0.5	0.15**
3rd i.a.	0.3	0.1	16*	0.5	
	$\Sigma = 4.1$			$\Sigma = 3.3$	$\Sigma = 0.25$

* = the number of 3rd i.a. belonging to one umbel;
** = total weight of 2nd and 3rd i.a.

Considering the length of the main and side shoots, and within them those of the internodia, as well as the state of development of the exemplars, it follows that the architecture of *P. anisum* consists at the examined stage of development of organs, or elements, of various development, weight and of assimilating surface whose distribution is dependent on the architecture.

Considering the distribution of the features examined above, it is quite probable that the distribution, diffusion, activity (pattern, cf. WARDLAW, 1965) of growth regulating materials keep certain side shoots constantly, others for a longer or shorter period of time, in a subpassive state, while in others they represent more favourable conditions, according to localization. Thus the origin localization of the side shoots in other words, the height zone within the architecture, is an important factor in determining the length of the side shoots. At the apex of the main and side shoots, the umbelliform arrangement in the same zone means an increase in surface and at the same time amasses the generative organs in great numbers, owing to the secondary and tertiary inflorescence axes. (Up to a certain point in the flowering of the main axis, the development of the flowers on the side shoots is inhibited.)

The assimilating surface and the weight distribution conditions correspond to, and reflect, the architecture of the plant.

The above results inspired us that, beyond investigating weight and assimilating surface characteristics, also a third one, concerning internodial length, be studied in 1974, in order to understand to what diverse rates the internodial height zones divide the main axis if their numbers and phenophases are different. Therefore, specimens with 8 nodes (sown in March 1973) have been compared to 16 specimens with 9 nodes (sown on 21 March, 1974, and gathered on 2 July), as far as their length data were concerned. The numerical data are given in Table 5.

According to Table 5, it is characteristics, in spite of the different numbers of nodes and phenophase, that the length of internodes increases upwards from internode 1 to 5 in the case of specimens with 8 nodes and from internode 1 to 4 in the case of specimens with 9 nodes. In the middle internodes, a state of equilibrium is observable in both examined phenophases, then the internode below the primary inflorescence axis is shorter i.e. the 7th in 1973, and the 7th and 8th in 1974. On the contrary, the uppermost one is the longest of all, irrespective of the number of internodia, in both years and in both phenophases, in fact identical with the primary inflorescence axis (henceforth p.i.a.). Similar internodal length distribution was measured by S.-WOLCSÁNSZKY (1972) in *Zea mays*.

The difference between the main umbel and the side shoots increased in 1974, as compared to earlier phenophases in 1973.

According to Table 5, the phenophases of plants sown with only 5 days of difference in the two years are different. The number of days between sowing

Table 5

The length distribution of the main inflorescence axis, according to internodal sequence, in 1973 and in 1974

Date	Phenophases	Average height in mm	Internode			
			serial no. in 1973	length in mm	serial no. in 1974	length in mm
19 June, 1973	21.4—23.2	364	1.	28	1.	32
	31.4.2—32.1		2.	32	2.	43
	34.4.1—34.4.2		3.	39	3.	51
	41.2		4.	41	4.	55
			5.	42	5.	41
2 July, 1974	22.4—23.2	485	6.	41	6.	43
	32.3.5		7.	40	7.	35
	35.3.2—35.3.3		8. + 9.*	50+31	8.	39
	42.1		10.**	20	9. + 10.*	62+35*
					11.**	45

* = combined heights of 2nd and 3rd i.a.;
** = height difference between main and side umbels

and examination was smaller in 1974 than in 1973, nevertheless, the former specimens were in a more advanced state of development than the latter. The quantitative developmental differences of the architectural elements, and within it the qualitative ones of the generative organs may be connected with the external, and at the same time changing, environmental effects exerting their influence indirectly.

Anise of a limited growth (cf. O'SVÁTH 1964) in 1973, may be characterized, on the basis of internodial length values, by MITSCHERLICH's S-shaped curve (cf. WENT, 1957). According to the data of the two years, this length distribution, at the blossoming of the main umbel, or subsequently, is valid, with slight variations also independently of the development of the side shoots.

Accordingly, the conditions of the assimilating surface and weight distribution per height zone (internodially) are only partly parallel with each other, and not uniform, separately and per zone (SZUJKÓ-LACZA—FEKETE showed, in *Euphorbia cyparissias*, the accumulation of organic matter in diverse organs per phenophase in 1974). In the present case, organic matter displays a distribution even in the same phenophase when examining the plant per internode. This is probably why the linear correlation is positive, but not significant between the surface and weight values per internode (s.l.). The internodal length and internodal weight correlation is positive and approximates the 10% significance level. The internodal length and the assimilating surface show a negative relation, and therefore is not significant.

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Acta Botanica Academiae Scientiarum Hungaricae, Tomus 21 (3—4), pp. 451—453 (1975)

RECENSIONES

WALTER, H.: Die Vegetation Osteuropas, Nord- und Zentralasiens, Vegetationsmonographien der einzelnen Grossräume. 7. vol. Stuttgart, G. Fischer, 1974, 452 pp., 363 illustrations, DM. 149.—

Earlier published volumes of the serial edited by H. WALTER (1. KNAPP: North and Central America, 2. HUECK: South America, 2a. HUECK—SEIBERT: Atlas of the vegetation of South America, 3. KNAPP: Africa) have been reviewed in the Botanikai Közlem. 64. (1974) and in the Acta Botanica Acad. Sc. Hung. 20, (1974). The recently published work gives a brief and modern treatment of the vegetation of Eastern Europe, North and Central Asia, thus practically of the Soviet Union. The well-known botanist was born in Odessa (as Mr. WALTER himself told me in 1928 when we met for the first time) he had an excellent command of the Russian language and for this reason was well equipped to undertake this task, although he became acquainted with the region only up to the Leningrad—Kiev—Rostov—Tbilisi—Baku line in his youth and later during the World War II. But the editor had at his disposal a very extensive Russian-Soviet literature, chiefly ALECHIN's "Vegetation of the USSR" 2nd edition, 1951, and the "Descriptio vegetationis URSS", (edited by LAVRENKO and SOCHAVA) an explanation of the 8 pages of vegetation atlas (1 : 4 million) by nearly 1000 pages (text in Russian). WALTER has treated the subject briefly in two of his earlier works, both of shorter length: "Die Vegetation Osteuropas" 2nd ed., Berlin (1943) and "Die Krim", Berlin (1943). The chief objective of this book was to cover plant associations (partly formations, but frequently also associations), submitting numerous analyses but not furnishing tables. The nomenclature relies on the terminology of Soviet authors, though consideration is given to larger units e.g. the steppe communities are divided into *Festuceto-Herbeta*, *Herbeto-Stipeta*, *Stipeta*, and thus rather ecological names, as *Suprahygroherbeto-Stipetum* or *Subpsammo-Herbeto-Stipetum*, originate. The methods of the former GROSSHEIM school, incorporating the thought orientation of the Central European School, are disregarded as well as the similar works of Hungarian cenologists who had visited the Soviet Union (BORHIDI, SOÓ, etc.). Relatively little literature is quoted: the extensive summary makes reference to Soviet bibliographies. Causative ecologic problems are not discussed here but in the 2nd vol. of the "Vegetation der Erde", 1968 (see Acta Botan. 15: 204—5 and 21:218). Hungarian botanists will find especially interesting the excellent summary on deciduous woods, wood-steppes and steppes. Numerous comparisons between the vegetation of the treated area and of the North American continent are offered. The book consists of several parts. In the introduction, the vegetation units, vegetation zones (unfortunately only two small sketch-type maps are presented), zonal, extrazonal and azonal vegetations, etc. are reviewed. The main chapters cover the followings: 1. Arctic deserts and tundras, 2. boreal coniferous zone, the taiga, 3. broadleaf and mixed broadleaf-coniferous woods, 4. nemoral (shady) deciduous forest zone with special view on the Ukraine (mixed oakwoods are discussed under the name of "Nemoreta"), 5. steppe, 6. semi-deserts and deserts, 7. mountains representing multiple zones: Ukraine, Altai, Krim, Caucasus. It is evident that the chapters follow the conventional pattern of division.

The different parts contain a large number of photographs of communities and some drawings; small and large size areal and floral maps, diagrams of climate, vegetation profiles are taken over from Soviet authors to a great extent.

The book has a pleasing appearance, like other publications of the Fischer publishing house. Its price is not low. Although the reviewer is one of the still living honorary members of the Soviet Botanical Society, he must at this place again state that in his view the com-

petent methodology of the Zürich—Montpellier school can be successfully applied to the field of vegetation, and therefore he does not share the approach of the KOMAROV school (see Flora USSR). According to the KOMAROV school, a species is monotypic, it represents an indivisible unit (this is true only for the genetic biotype). Such an approach will lead to the disregard of geographic races (subspecies) and ecotypes, these and scarcely different forms are denoted as species, especially by Ukrainean botanists, these taxa have been contracted both in my synopsis and in the Flora Europea (for a counter opinion to BOBROV's view, see the expounding by SKORSTOV, 1972). More recently, as I indicated elsewhere, I am inclined to accept next to the traditional German-British sp., subsp., var. concepts also (in the critical genera) the agg. (aggregatum: spec. coll.) and the small species (microspecies), though these cannot be traced in the Code, International Code of Nomenclature.

In the last analysis, WALTER's work is an excellent summary and the only book which gives a modern account of the vegetation of the Soviet Union and which can be used by those who are not versed in the Russian language. It is a want for the Hungarian geobotanist.

R. Soó

Å. LÖVE and D. LÖVE: Cytotaxonomical Atlas of the Slovenian Flora. Lehre, Cramer Verlag, 1974. 124 pp.

Åskell LÖVE is rightly regarded as the best qualified authority in the field of cytotaxonomy. Though his last and most extensive work, "Cytotaxonomical Atlas of the Slovenian Flora", covers a small geographical area, it is of immediate interest to the Hungarian botanists as well as to the European taxonomist. It contains all data made available so far (up to 1972) of most plant species in Hungary, and includes pertinent literature quotations. In this respect, the work of the LÖVES excells over their earlier book ("Chromosome number of Central and Northwest European plant species") — in which Hungary is considered as an integral geographic part of Central Europe — and over the book of the most comprehensive scope by BOLHKOVSKIKH, GRIF, MATVEYEVA and ZAKHARYEVA, entitled "Chromsome number o flowering plants" published in Leningrad in 1969, which deals with all existing flowering species of the world; however because of the lack of adequate critical approach, it is not infrequent that data on identical plant species are given under various synonyms (e.g. *Orchis maculata*, *Dactylorchis maculata*, *Dactylorhiza maculata*) and that a number of obsolete and questionable data are included, especially in the case of sp. agg. (e.g. *Festuca ovina*), regrouped recently into smaller species. Yet this work is indispensible even to-day. (At this point, I call attention to the fact that the chromosome numbers published between 1965 and the present time can be found in the volumes of 50. et seq. of Regnum Vegetabile, compiled by ORNDUFF and MOORE.) Literature on biosystematics (including cytotaxonomy) published between 1945 and 1960 can be found in the bibliography of SOLBRIG and GADELLA (Biosystematic literature, Utrecht, 1970, 566 pp. according to families and genera). These fundamental works are mentioned here in conjunction with that of the LÖVES, because nowhere does Hungarian botanical literature make mention of them. The LÖVES cite the relevant works of Hungarian botanists on pages 797—1223, thus making it the most complete enumeration. Exaggerated are — as in their other works — the splitting of some genera (under the names of *Centaurea*: *Acrolophus*, *Acosta*, *Phalolepis*, *Jacea*, *Leucantha*, *Calcitrapa*, *Cyanus*, *Colymbada*, *Acrocentron* and similarly in the case of *Polygonum*, *Rumex*, etc. and even in the very much subdivided *Orchis* there appeared *Vermeulenia*). Some Czechoslovakian botanists, e.g. DOSTÁL, HOLUB and others, approach classification on a similar basis. The enumeration follows ENGLER's system, seldom including subspecies if the representatives are of different cytotypes in which case they are treated as a separate species (as in their earlier works) and thus the resultant number of the micro-species is high. The names of species are accompanied by a 10 digit code number in order to aid computer processing although it would have been more advantageous to supply the page number in the index. The work contains quite a few new or even striking statements concerning microsystematics, but ignores chromosome numbers which are uncommon, for example in the instance of grasses (*Agrostis*, *Dactylis*, etc.). Theoretically, it is sound that *F. valesiaca* and *F. pseudovina* are 2n: 14, and that *F. rupicola* is 2n: 42, but I know *F. valesiaca* and *F. pseudovina* unquestionably polyploid (28 !) in flower morphology as well as in leaf anatomy from Hungary then a number of divergent 2n plants in the earlier *A. alba* agg. — certainly hybrids or aneuploids to some extent — but *prorepens* Koch 2n: 70 (not treated in this work) can be regarded as a distinct species = *A. stolonisans* Bess. (See Soó: Synopsis . . . Fl.-Veg. Hung. 5. pl. 1., *Festuca* in Acta Bot. Hung. 18. 1972, 363—377). The nomenclature, in general, is extraordinarily precise and up to date; however, it is confused

in *Rhinanthus*, because *Rh. major* auct. is not *Rh. alectorolophus* but *Rh. angustifolius* Gmel. (*Rh. serotinus* [Schönheit] Oborny), *Rh. aristatus* Čelak. is correctly *Rh. glacialis* Personn. (see Soó in Feddes Rep. 84: 448). Other remarks will be made in vol. 6. of the Synopsis. Despite these few critical remarks, the book published by the Löves is the most reliable handbook on cytotaxonomy and it can be only wished that the authors would expand it to cover the entire European flora. The book is rotaprinted, has an aesthetically appealing cover but is sold at a prohibitive price.

R. Soó

Leuschner, D.: Einführung in die numerische Taxonomie. Jena, VEB Fischer, 1974, 139 pp.

Albeit, the reviewer is no adherer of the numerical taxonomy, since in biology (both in taxonomy and ecology) it is the qualitative characteristics which are fundamental and the quantitative characteristic only if the dialectical conversion into the qualitative takes place, nevertheless, the book is to be recommended. The numerical taxonomists or the taxometrist considers in the strict application of his discipline each pair of data as of equal value (axiom no. 2), but it is not indifferent whether a plant has 1 or 2 cotyedons if the leaf is 1 or 2 cm wide. (This of course is an absurd example.) The EDVA, i.e. the automatic processing of data material has as its purpose objectivity, the capacity of reproduction and rapidity. The author himself discusses the multiplicity of characteristic marks (Merkmale) and in the 5th axiom he states the principle of independence of similarities as taxometrically founded. (Not long after the new system has been constructed [Sokal and Sneath, 1963], a serious debate evolved in Liverpool in 1964 [see Heywood and McNeill: "Phenetic and phylogenetic classification" 1964, London].) Ehrendorfer has stated long before in the "Fortschritte d. Botanik" that numerical taxonomy has produced excellent results — especially with respect to microorganisms — but absurd ones as well. In order to fully comprehend this book, it is necessary for the reader to be equipped with the tools of mathematics. A vaste number of new concepts (also biological ones), and of abbreviations along with a number of taxometric methods are presented. Many concepts are discussed in the quadrilingual appendix which is, however, not complete. Among the Hungarian biologists, Juhász-Nagy and Orlóczy (now professor Orloci in Canada) are mentioned in the literature.

R. Soó

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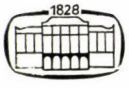

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НОВЫЕ РАСТЕНИЯ НА КУБЕ IV

А. БОРХИДИ, О. МЮНИЦ

В настоящей статье описано 24 новых таксона: *Polygonaceae: Coccoloba* (lsp.); *Euphorbiaceae*: (*Leucocroton*) (l sp.); *Sapindaceae*: *Thouinia* (l sp.); *Celastraceae*: *Crossopetalum* (lsssp. 1 var.); *Rhamnaceae*: *Auerodendron* (l var.), *Reynosia* (l sp.); *Combretaceae*: *Terminalia* (l sp.), *Bucida* (l sp.); *Myrtacea*»: *Psidium* (l sp.), *Calycorectes* (l sp.), *Pimenta* (l sp.), *Murcia* (l sp.), *Myrtus* (1 sp., 1 hybr.), *Eugenia* (1 sp.); *Melastomataceae*: *Calycogonium* (1 sp.); *Sapotaceae*: *Bumelia* (1 sp.); *Scrophulariaceae*: *Bacopa* (1 sp.); *Rubiaceae*: *Schmidottia* (1 var.); *Rondeletia* (1 sp.).

ИЗУЧЕНИЕ АНАТОМИИ ГЕНЕРАТИВНЫХ ОРГАНОВ LOTUS CORNICULATUS AGG.

О. БОРШОШ

Автор изучала анатомию частей цветков 7 диких и 3 культивируемых таксонов *Lotus*. В статье автор дает подробное описание строения цветка мотыльковых, который состоит из чашечки, лепестков, тычинок и пестика, далее описана анатомия плода и семени.

ЭКОЛОГИЧЕСКИЕ НАБЛЮДЕНИЯ НАД ВЕНГЕРСКИМ ВОДНЫМ HYPHOMYCETES

И. ГЕНЦЕЛЬ

Статья публикует данные о распространении водного *Hyphomycetes* в венгерском горном ручье (ручей Морго, гора Бержень), который исследуется уже много лет, а также об отношениях сезонного существования отдельных видов или совокупности видов. В исследуемом ручье можно определить две хорошо отличимые видовые совокупности, довольно резко обособленные друг от друга. На основании ранее сделанных наблюдений, главная причина этой изоляции: субстрат-преференция отдельных видов грибов. Дальнейшие результаты, которые публикуются в статье, это данные о таких видах водного *Hyphomycetes*, у которых сезонное существование показывает связь с годичной температурой воды а также с опаданием листьев.

НОВЫЕ ВИДЫ SCENEDESMUS, НАЙДЕННЫЕ В БУДАПЕШТСКОЙ ЧАСТИ ДУНАЯ

Т. ХОРТОБАДЬИ

В статье сообщается о четырёх новых видах *Scenedesmus* из коллекции, собранной в будапештской части Дуная в 1971—1972 году. Автор посвящает эти виды венгерским гидробиологам: (др. А. Берцик, др. И. Киш, др. Г. Семеш, др. Г. Уеркович).

ДЕЙСТВИЕ МОНОХРОМАТИЧЕСКОГО СИНЕГО И КРАСНОГО СВЕТА НА ЭЛЕКТРОННОМИКРОСКОПИЧЕСКУЮ СТРУКТУРУ ХЛОРОПЛАСТА

И. ХОРВАТ, Ф. КАЛЬМАН, Е. А. ТИТЛЯНОВ

В паприке, выращенной на близком монохроматическом синем и красном свете, количество гран в хлоропласте, а также количество гран-везикулум растет параллельно с ростом длины волны. Продукция фотосинтеза в первую очередь зависит от количества гран.

КРИОБИОЛОГИЧЕСКИЕ ИССЛЕДОВАНИЯ В ВЫСОКИХ ТАТРАХ II.

Е. КОЛ

Первая часть этой работы была опубликована в журнале Acta Bot. Hung. 1975 21 (1—2). В этой части статьи таблица обобщает комплекс микроорганизмов растений, живущих на снежной поверхности Высоких Татр, а также изображает их распространение и распространение различных криобиотопов. Снежная вегетация Высоких Татр очень разнообразна. Здесь были найдены также микроорганизмы, которые живут в дальних районах. Высокие Татры, благодаря своему центральному расположению являются важным центром с точки зрения аэробиологии. Здесь можно найти криобионты, которые живут в северном полушарии, а также отдельные виды, живущие в южном полушарии. В статье описана III часть криобиологических исследований, проводимых на территории Высоких Татр.

СРАВНИТЕЛЬНЫЕ ПОЧВЕННО-АЛГОЛОГИЧЕСКИЕ ИССЛЕДОВАНИЯ НЕКОТОРЫХ ТИПОВ ПОЧВ ГОРЫ МАТРА

Ж. П. КОМАРОМИ

Автор с точки зрения алгологии исследовала типы почв, которые чаще всего встречаются на среднегористых местностях Венгрии, а также и на горе Матра. В результате полученных данных были сделаны выводы о видовом составе альгофлоры отдельных типов почв, а также выводы, относяшиеся к связи между алгофлорой и почвенными факторами. Автор определила из 120 образцев почвы, применяя метод размножения, 35 видов водорослей. Между этими видами 16 было зелёной, 11-желтой и 8 диатомовой водорослью. Синяя водоросль найдена не была.

МОРФОЛОГИЧЕСКИЕ ИССЛЕДОВАНИЯ СПОР ЕВРОПЕЙСКИХ ВИДОВ ENCALYPTA, СУЩЕСТВУЮЩИХ В НАСТОЯЩЕЕ ВРЕМЯ

М. ЯРАИ-КОМЛОДИ, Ш. ОРБАН

Авторы провели морфологический анализ спор европейских видов *Encalypta* при помощи микроскопа и электронного микроскопа сканнинг. На основании морфологических отличий спор внутри рода, авторы предположили, что род *Encalypta* заключает в себе некоторые таксономические и филогенетические неясности. Публикуется подробное палинологическое описание спор 9 видов *Encalypta*, этим авторы приблизились к решению таксономической проблемы. Таксономия семейства *Encalyptaceae* еще не достаточно ясна, поэтому авторы планируют дальнейшие палинологические исследования, относящиеся к целому семейству.

ИЗМЕРЕНИЯ КАЛОРИЙНОСТИ ДОМИНАНТНЫХ РАСТЕНИЙ ДУБОВОГО ЛЕСА (QUERCETUM PETRAEAE-CERRIS) (ШИКФЕКУТ, СЕВЕРНАЯ ВЕНГРИЯ)

Л. Б-НАПП

Статья содержит данные о калорийности и энергии фитомассы доминантных растений венгерского дубового леса (*Quercetum petraeae-cerris*). Была измерена и вычислена калорийность растений во многих фракциях, а также по каждому уровню (уровень деревьев, кустарников и мягкостебельных). На основании полученных результатов можно отметить, что калорийность понижалась от уровня деревьев в сторону мягкостебельных. Была определена калорийность: на уровне деревьев 4657 кал/гр, на уровне кустарников 4476 кал/гр, а на уровне мягкостебельных 4379 кал/гр. На отдельных уровнях нет значительных различий между калорийностью видов. Однако, большие различия в калорийности листьев и луба были отмечены у различных видов. Более гомогенная была древесина. На основании калорийности и фитомассы (в сухом весе) определили, что содержание энергии доминантных растений равнялось: 113,646x10^{7}Ккал/га.

НОВЫЕ ИЛИ МАЛОИЗВЕСТНЫЕ ПЕЧЕНОЧНИКИ (ЭПИФИТЫ НА ДЕРЕВЬЯХ) I. COLOLEJEUNEA ИЗ ТРОПИЧЕСКОЙ АФРИКИ

Т. ПОЧ

Автор описывает следующие виды: *Cololejeunea fadenii* spec. nov. из Кении, *Cololejeunea harrisii* spec. nov. и *C. jonesii* spec. nov. из Улугуру, Танганьика. Автор дополняет описание вида *C. usambarica* E. W. Jones. Вид *Aphanolejeunea runssorensis* Steph. автор переносит к *Cololejeunea* и синонимизирует с видом *C. leonardii* Vanden Berghen.

О НЕКОТОРЫХ РАСТЕНИЯХ ЗАПАДНОГО ТЯНЬ-ШАНЯ I

С. ПРИСТЕР

Автор описывает однолистную модификацию *Allium karataviense* Rgl. (var. *granitovii*). которая произрастает в заповеднике Западного Тянь-Шаня «Чаткальский Заповедник». Далее автор выясняет синонимику и распространение видов *Sedum alberti* Rgl. и *Sedum ewersii* Ledeb., растущих в западном Тянь-Шане. Автор определяет, что *S. ewersii* var. *homophyllum* Praeg. находится там в диком состоянии, а также описывает новую круглолистную модификацию (var. *cyclophyllum*).

КЛЮЧ К ОПРЕДЕЛЕНИЮ СИСТЕМАТИКИ ИЗУЧЕННЫХ ВИДОВ STREPTOMYCES И STREPTOVERTICILLUM В РАМКАХ МЕЖДУНАРОДНОГО ПРОЭКТА ПО STREPTOMYCES

И. М. САБО, М. МАРТОН, И. БУТИ, Е. ФЕРНАНДЕЗ

В статье предлагается ключ к определению изученных в рамках МСП, 414 «видов» *Streptomyces* и *Streptoverticillum*.

Этот ключ основывается на критериумах, которые были отчасти изменены Международным Проэктом по *Streptomyces*.

Этот ключ дает возможность специалистам, занимающимся систематикой, выбирать из международной коллекции штаммов те близкородственные (к определяемым штаммам) или неотипные культуры, а также дает возможность для корректной идентификации этих штаммов, которые одновременно были сравнены по морфологическим и физиологическим свойствам.

ГОДИЧНОЕ ИССЛЕДОВАНИЕ СОДЕРЖАНИЯ ПИТАТЕЛЬНЫХ ВЕЩЕСТВ ОСАДКОВ, ПРОНИКАЮЩИХ ЧЕРЕЗ ЛИСТВУ В ДУБОВОМ ЛЕСУ (QUERCETUM PETRAEAE-CERRIS)

М. САБО, Ч. ЧОРТОШ

В статье публикуются данные 1974 года об изучении циркуляции минеральных веществ в лесной экосистеме (*Quercetum petraeae-cerris*), в частности о содержании минеральных веществ, находящихся в осадках и проникающих через листву в почву.

Авторы исследовали 11 элементов, находящихся в атмосферных осадках, а также в воде, проникающей через листву. Зная количество воды, концентрацию и лиственный покров, было вычислено, что в период опытов (с 27 февраля 1974 года по 4 декабря 1974 года) на гектар почвы, с водой, проходящей через листву 27,017 кг. калия, 23,88 кг. кальция, 4,55 кг. магния, 1,84 кг. натрия 1,39 кг. марганца, 0,21 кг цинка, 0,18 кг. железа а также 4,67 кг. серы (из сульфата), 17,28 кг. азота, 12,88 хлора и 2,08 кг. фосфора (из фосфата) поступило в почву. Вода, проходящая через листву была более всего обогащена калием и серой (максимум насыщения был в августе и ноябре).

По сравнению с атмосферными осадками степень насыщения различными элементами: калием в 1,2—30,1 раз, кальцием в 1,1—6,4 раза, магнием 1,1—13,0 раза, марганцем в 2,2—70,9 раз, серой в 1,2—8,0 раза, фосфором 1,4—11,0 раз. Максимум насыщения азотом и фосфором совпадал с майской градацией гусениц.

ЭЛИМИНАЦИЯ ХРОМОСОМ У АЛЛОПЛОИДНОГО ГИБРИДА NICOTIANA TABACUM (KENTUCKY)×N. GLAUCA

Л. СИЛАДЬИ

Автор провела цитогенетические исследования с аллоплоидным гибридом *N. tabacum*×*N. glauca*. Первое поколение гибрида было интермедиерным с правильным мейозом. Во втором, третьем и четвертом поколении наблюдалось расщепление гибридных растений. В четвертом поколении аллоплоида были селектированы 5 растений с белыми цветами. Эти растения и в пятом поколении остались стабильны. В соматических клетках они содержали вместо 72, 48 хромосом.

Автор приготовила кариотип 48-хромосомных растений и определила, что элиминирующие 12 пар хромосом относились к геному *N. tabacum*.

КОЛИЧЕСТВЕННЫЕ ИССЛЕДОВАНИЯ НЕКОТОРЫХ СВОЙСТВ И АРХИТЕКТУРЫ АНИСА, PIMPINELLA ANISUM L.

Й. СУЙКО-ЛАЦА, З. СЁЧ

В статье авторы, вместо менее точного определения понятия морфологии, адоптируют и снова обьясняют понятие архитектуры, которое было дано Devades и Beck (1971), для того чтобы приблизиться к объяснению функций пространственных отношений органов растений между собой. В растении в одно и тоже время можно найти органы, которые различны по развитию, весу, и ассимилирующей поверхности (элементы архитектуры). Разделение значений длины интернодиумов, из которых построен главный стебель, у видов с ограниченным ростом, отмечается кривой Mitscherlich S. Длину растения и стеблевых черешковых листьев изображает парабола. Сухой вес каждого интернодиума и ассимилирующей части только отчасти параллельны друг с другом. Уже в начале цветения главного зонтика самое большое весовое отношение дают: первичный цветочный стержень, относящийся к нему главный зонтик, также побочные стебли и листья. Нет сигнификантной линейной корреляции между сухим весом высокой зоны и ассимилирующей поверхности. Эти результаты показывают, что поверхность, вырабатывающая органические вещества и аккумуляция находятся в различных местах.

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